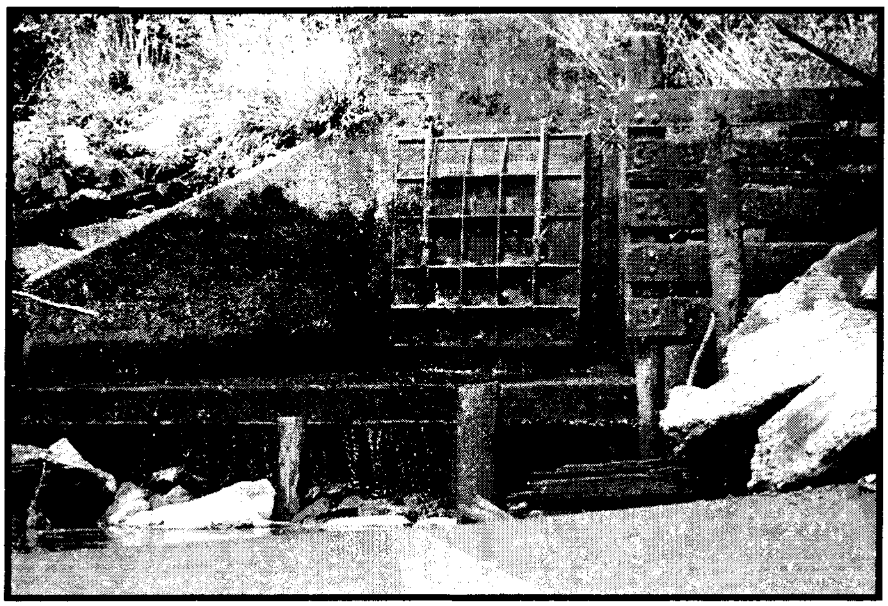
Combined Sewer Overflow Control Plan Year 2000 Update

June 2000



King County
Department of Natural Resources

Brown & Caldwell, Inc.

Combined Sewer Overflow Control Plan Year 2000 Update

King County Department of Natural Resources
Wastewater Treatment Division
201 S. Jackson Street, MS KSC-NR-0503
Seattle, WA 98104

June 2000

King County Department of Natural Resources//Brown & Caldwell, Inc.

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EXECUTIVE SUMMARY

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Combined sewer overflows, or CSOs, are discharges of untreated sewage and stormwater released directly into lakes, rivers, and marine waters during periods of heavy rainfall. King County has 37 CSOs within the City of Seattle. As the collection system was configured in 1983, King County combined sewer outfalls discharged nearly 2.3 billion gallons of CSO in an average year of rainfall. Since 1988, the County and its predecessor, Metro, have undertaken a number of projects to reduce the volume and frequency of CSOs. King County is committed to reducing CSOs even further in the years ahead.

Why a Year 2000 CSO Control Plan Update?

Besides being required by state regulations, this report documents King County's compliance with state and federal CSO control requirements.

What Has Happened Since the 1995 CSO Update?

The *Regional Wastewater Services Plan* (*RWSP*) was reviewed and approved by the King County Council. The *RWSP* outlines wastewater projects to be built over the next 30 years to protect human health and the environment, serve population growth, and meet regulatory requirements. The *RWSP* is the County's new CSO Control Plan. It includes over twenty CSO control projects to reduce CSOs to one untreated event per year on average at each CSO location. This report updates the *RWSP* CSO Control Plan. In addition, new studies, initiatives, and regulations have developed which impact CSO planning and control. These include redefining a CSO event, studying alternative methods for CSO control and treatment, researching potential total maximum daily load (TMDL) requirements, developing watershed management programs, studying sediment contamination and developing a sediment management plan, potential listing of the Duwamish River as a Superfund site, developing a CSO posting and notification program, and listing of Chinook salmon under the Endangered Species Act.

What Has King County Achieved in CSO Reduction?

King County CSO volume is approximately 1.5 billion gallons per year—this is an almost 1 billion gallon reduction from our 1981-83 baseline volume of 2.3 billion gallons.

What Are King County CSO Projects for the next 5 Year NPDES Permit Cycle?

Two CSO projects are underway. The Denny/Lake Union CSO Project will reduce CSO discharges from King County's largest CSO from approximately 50 untreated discharges per year on average to one untreated discharge per year on average. This project includes a tunnel for storage and CSO treatment. For very large storms, about half of the volume will be transferred to the West Treatment Plant for treatment; the remainder will be treated on-site and discharged to Elliott Bay. This project is expected to be completed by mid-2004.

The Henderson/Martin Luther King Way Project will reduce CSO at three CSO locations (Henderson, Martin Luther King Way, and Norfolk) to one untreated discharge per year on average at each of these CSO locations. It includes a treatment tunnel that discharges treated CSO into the Duwamish River from the Norfolk CSO location. It is expected to be completed by 2004.

What are King County's Future CSO Projects?

Under the *RWSP*, there are over 20 projects to be completed by 2030. The first priority projects are locations near bathing beaches. Thus, discharges along Puget Sound beaches and the east end of the Lake Washington Ship Canal are scheduled for completion by 2015. The Duwamish River discharges are second in priority and are scheduled for completion by 2027. Since significant CSO control had already been accomplished in the west end of the Ship Canal, facilities to control CSOs in this area have last priority and are scheduled for completion by 2030. The following figure shows the priority of projects making up the CSO element of the *RWSP*.

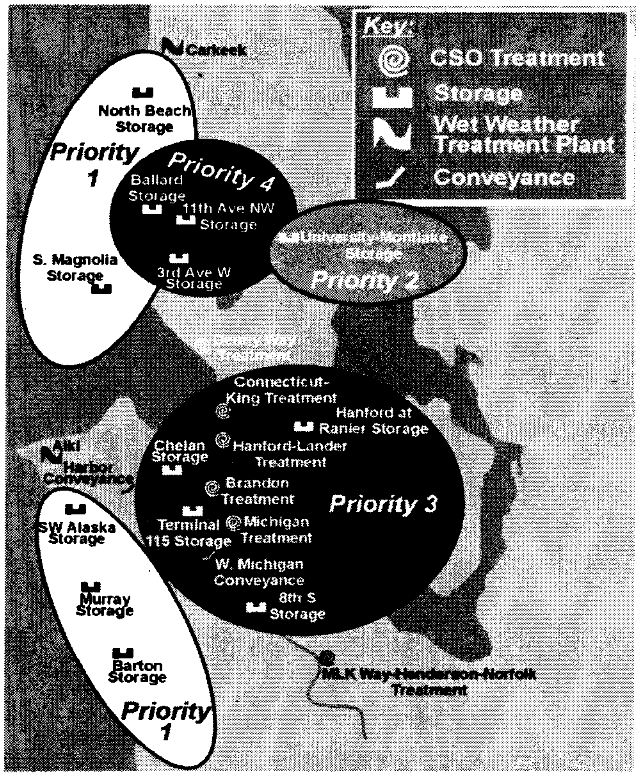

Figure ES-1: Priority of CSO Control Projects

It is possible that King County may modify the proposed schedule or projects before they are built in order to take advantage of some new technology, to increase project cost-effectiveness, or because of changing conditions. In addition, the order of projects might need to be changed, with individual projects accelerated to accommodate fish recovery, planning being undertaken on other issues, or sediment remediation efforts. Because the primary objectives of all the CSO projects--protection of human health, fish and wildlife, and receiving water quality--are consistent with the goals of those efforts, significant changes in the overall schedule do not appear likely. The following table outlines the projects and their costs in 1998 dollars.

Table ES-1: CSO Projects in the RWSP

CSO Project	Project Description	1998 Capital Cost, $mil	Year Controlled
Completed *1988 Plan* Projects		$60.5	1997
Committed Projects[a]		$194.9	2004
S. Magnolia	1.3 MG storage tank	$6.8	2010
SW Alaska St.	0.7 MG storage tank	$4.3	2010
Murray	0.8 MG storage	$5.1	2010
Barton	Pump station upgrade	$9.3	2011
North Beach	Storage tank and pump station expansion	$3.9	2011

Table ES-1: CSO Projects in the RWSP			
CSO Project	**Project Description**	**1998 Capital Cost, $mil**	**Year Controlled**
Univ+Montlake	7.5 MG storage	$53.5	2015
Hanford #2	3.3 MG storage/treatment tank	$27.9	2017
West Point Improvements	Primary/secondary enhancements	$16.9	2018
Lander	1.5 MG storage/treatment at Hanford	$26.0	2019
Michigan	2.2 MG storage/treatment tank	$32.4	2022
Brandon	0.8 MG storage/treatment tank	$13.1	2022
Chelan	4 MG storage tank	$18.3	2024
Connecticut	2.1 MG storage/treatment tank	$31.9	2026
King St.	Conveyance to Connecticut treatment	$3.2	2026
Hanford at Rainier	0.6 MG storage tank	$3.3	2026
8th Ave S	1.0 MG storage tank	$6.9	2027
West Michigan	Conveyance expansion	$0.4	2027
Terminal 115	0.5 MG storage tank	$3.9	2027
3rd W	5.0 MG storage tank	$28.3	2029
Ballard	1.0 MG storage tank (40% King County)	$2.9	2029
11th Ave. West	2.0 MG storage tank	$12.9	2030
Totals		**$566.6**	

[a] Includes Harbor, Denny, Dexter, Norfolk and Henderson/MLK Way

CHAPTER 1

CHAPTER 1
INTRODUCTION

Combined sewer overflows, or CSOs, are discharges of untreated sewage and stormwater released directly into marine waters, lakes, and rivers during periods of heavy rainfall. This *Year 2000 Combined Sewer Overflow Control Plan Update (2000 CSO Update)* reviews King County's CSO problem and identifies the steps the County is taking to solve it.

As part of the renewal process for its National Pollutant Discharge Elimination System (NPDES) permit for the West Point Treatment Plant, King County is required by Section 173–245-090(2) of the Washington Administrative Code (WAC) to prepare an update of its CSO reduction plan. The update must include an assessment of the effectiveness of CSO reduction efforts to date, a re-evaluation of priorities for CSO control projects, and a list of projects planned for the next five years. This report updates the RWSP CSO Control Plan.

Chapter 1 provides a brief background of the CSO problem and an overview of federal and state laws and regulations requiring CSO control. Other regulatory provisions that indirectly require control of overflows or govern the manner in which control efforts must be carried out are also mentioned. The chapter also includes a short history of King County's control efforts and concludes with a summary of the contents of this document.

King County's CSO Problem

When a new house is constructed or a new neighborhood is developed, contractors install sanitary sewers (to carry untreated sewage to a treatment plant) and storm drainage (to channel rain from rooftops, driveways, sidewalks, streets, and other impervious surfaces to the nearest waterbody). This type of system is called a separated sewer system. Separated systems are now considered standard engineering practice, but that was not always the case. A hundred years ago, the common practice was to provide a single sewer pipe to carry both sanitary sewage and stormwater runoff, thereby managing both human and horse waste (the primary mode of transportation at the time). Until the early 1940s, nearly all sewers constructed in Seattle were combined sewers; separated sewers have been mandatory since about 1950. The City of Seattle is the only sewerage agency served by King County that has a combined sewer system. Figure 1-1 illustrates separated and combined sewer systems.

In combined sewer systems wastewater flows are fairly constant, but stormwater runoff fluctuates greatly, depending on both the amount of rainfall and the ability of the soil to absorb that rainfall. During large storms in a combined sewer system, more rainwater may run off than a given size pipe can handle.

CSOs act as sewer system relief valves. CSOs protect treatment plants from huge influxes of water that exceed the capacity of the plant as well as preventing sewage from backing up into streets and basements during severe storms. However, CSOs release potentially harmful bacteria and pollutants, may cause aesthetic degradation, and may reduce sediment quality near their discharge sites.

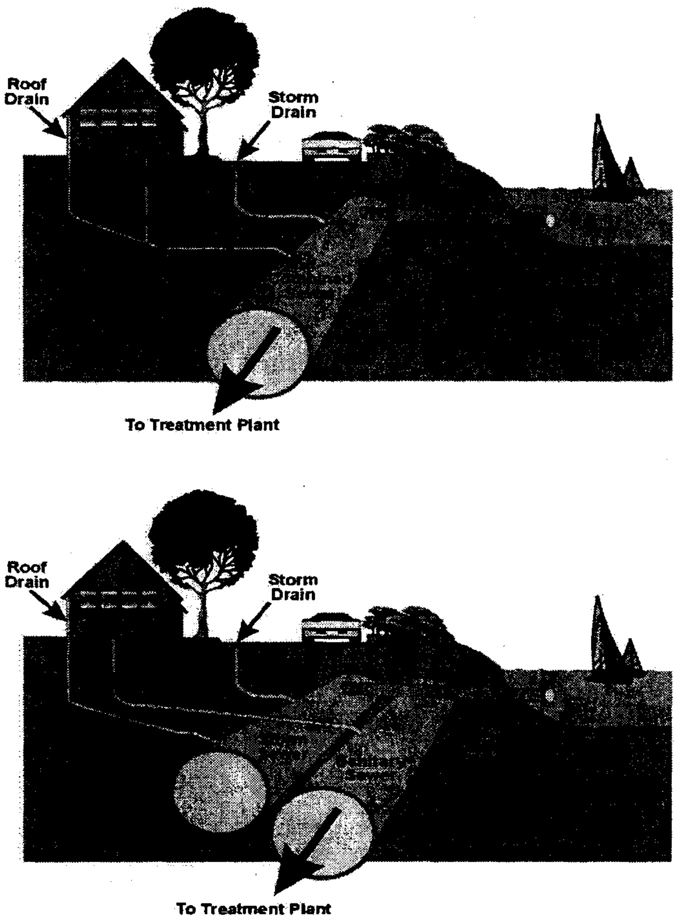

Figure 1-1: Combined and Separated Systems

King County CSO Reduction

About 5 percent of King County sewer revenues go toward controlling King County CSOs located along the shorelines of Lake Washington, Lake Union, the Lake Washington Ship Canal, the Duwamish River, Elliott Bay, and Puget Sound. Between 1981 and 1983, the baseline period for early CSO control planning efforts, King County overflows discharged nearly 2.3 billion gallons of combined sewage each year. Since that time, the County has undertaken a number of CSO control projects that have reduced the annual average volume of overflows to about 1.5 billion gallons. King County is committed to reducing CSOs even further in the years ahead. Figure 1-2 shows the progress made by the County in reducing CSOs. In general, CSO projects that resulted in the most amount of CSO volume reduction were done first. Future projects tend to be smaller volume projects. They are also more expensive as costs tend to increase when doing many smaller volume projects spread over the service area versus doing a few large volume reduction projects.

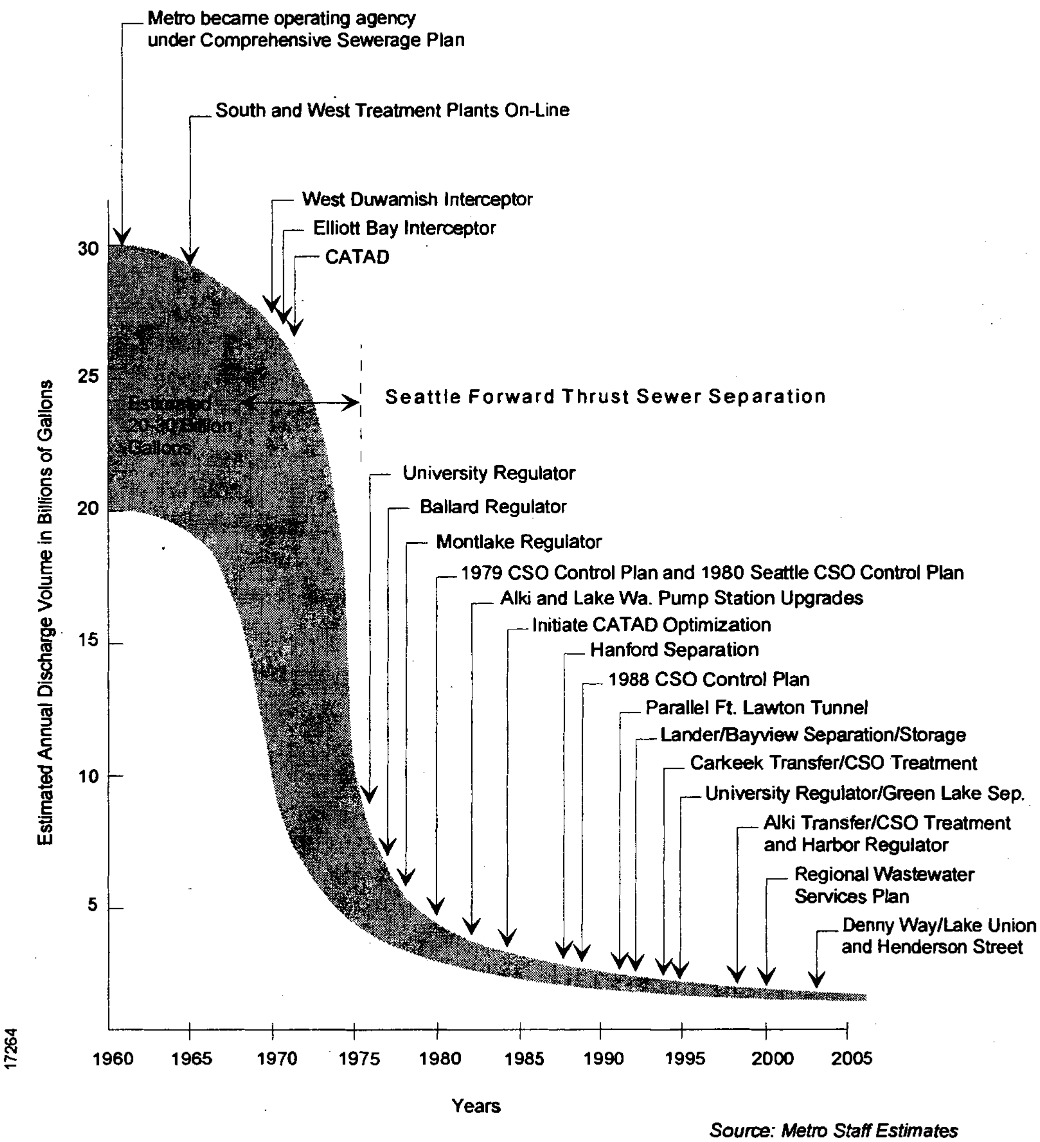

Figure 1-2: King County CSO Reduction Over Time

Program Motivation/Regulatory Framework

Several factors were involved in the development of wastewater treatment programs, plans, and projects in King County. First, the wastewater treatment side of King County was formed as Metro in the 1950s due to citizens' concern over the degradation of water quality in Lake Washington and the future of other water bodies in King County. Then in the 1960s up through the present, state and federal laws were passed that triggered the need for King County/Metro[1] to further develop water quality programs, plans, and projects. Some of the major laws and their impacts are listed in Table 1.

Table 1-1: Legal Requirements/Policies

Year	Legal Requirement or Policy	Impacts
1945	Creation of the Washington State Pollution Control Commission and enactment of Revised Code of Washington (RCW) 90.48	A water quality based regulation; it did not allow strong enforcement as pollution control was a negotiation process and required the state to demonstrate a water pollution control problem and assign the cause of that problem to a specific discharger.
1948	Federal Water Pollution Control Act (PL 80-845)	Provided some funds for the design of municipal wastewater treatment plants and for the study of water pollution problems.
1956, 1961	Federal Water Pollution Control Act and Amendments (PL84-660; PL 87-88)	Established federal grants for construction of municipal treatment plants.
1965	Federal Water Quality Act (PL 89-234)	Required states to adopt water quality standards for interstate waters.
1971	Washington State Pollution Disclosure Act (Chapter 90.52 RCW)	Discharger to use all "known, available, and reasonable methods of treatment prior to" discharge.
1972 and revisions	Clean Water Act (PL 92-500)	Objective of the law was "to restore and maintain the chemical, physical, and biological integrity of the Nation's waters." Also, included the creation of the National Pollutant Discharge Elimination System (NPDES) Permit program and required CSO control planning.
1973	Federal Endangered Species Act (ESA)	Intended to protect species of plants and animals that are threatened with extinction. The statute prevents actions that would harm a listed species or impair its habitat. In 1999, the National Marine Fisheries Service listed the Puget Sound Chinook salmon as "endangered." Because the receiving waters to which King County CSOs discharge are part of the salmon's historic habitat, actions that might impact those receiving waters are subject to regulation under the ESA.
1973	Amendment to Washington State Chapter 90.48 RCW	Requires all public sewerage agencies to obtain a permit before discharging any sewage, treated or untreated. The Washington State Dept. of Ecology (Ecology) was given jurisdiction by EPA to issue permits and thereby control water pollution within the state and to adopt rules and regulations necessary to that end.
1970s, 1980s, 1990s, 2000s	NPDES Permits and Renewals	The principal enforcement mechanism of the federal Clean Water Act is the NPDES permit. The NPDES permit issued by Ecology ensures compliance with both federal and state water pollution control laws. Ecology does not issue separate NPDES permits for each King County CSO discharge point. Rather, CSOs are included in the County's West Point Treatment Plant permit because County CSOs are part of the conveyance system leading to the West Point plant. NPDES oversight of CSO control, including any issues regarding

[1] For plans developed before 1995, Metro, instead of King County is used, as Metro was the agency providing wastewater conveyance and treatment service from 1958 to 1993. In 1994, Metro merged with King County into one government agency.

Table 1-1: Legal Requirements/Policies

Year	Legal Requirement or Policy	Impacts
		compliance with the Nine Minimum Controls and long-term planning requirements, is handled as part of the West Point permit renewal process that occurs approximately every five years.
1985	Washington State HB 815 (RCW 90.48.460 to 490)	All municipalities with CSOs to develop plans for "the greatest reasonable reduction at the earliest possible date."
1987	Washington State Chapter 173-245 WAC	Greatest reasonable reduction defined as a level of control such that an average of one untreated discharge may occur per year. CSO treatment defined as any process that removes at least 50% of the total suspended solids from the waste stream and discharges less than 0.3 milliliters per liter per hour of settleable solids. Disinfection may be required.
1990	Federal CSO Policy	Requires implementation of the Nine Minimum Controls; allows jurisdictions to use either a demonstration or presumption approach; presumption approach allows four to six untreated discharges per year and demonstration approach allows for 0 to more than six untreated discharges per year depending on whether discharges will violate water quality standards; allows for 35% removal of total suspended solids for CSO treatment. The federal CSO Control Policy has not been codified and is not an enforceable requirement in states delegated to manage their own NPDES permits.
1991	Washington State Chapter 173-204-120 WAC	Sediment Management Standards provide that existing beneficial uses of the benthic environment must be protected, and no degradation that would interfere with those uses is allowed. Part III of the regulation specifies sediment quality criteria for marine sediments, including Puget Sound and Elliott Bay. Part IV of the regulation, which provides for sediment source control standards, is used as a condition for the issuance of a NPDES permit.
1992; sections revised in 1997	Washington State Chapter 173-201A WAC	Includes the water quality standards for Washington's surface waters. The purpose of this chapter "is to establish water quality standards . . . consistent with public health and public enjoyment thereof, and the propagation of fish, shellfish and wildlife. . . ." • Chapter 173-201A-011 allows for CSOs complying with Chapter 173-245 WAC, an average once per year exemption to the numeric size criteria for mixing zones • Chapter 173-201A-030 establishes five surface water classes and defines the beneficial uses associated with each class. • Chapter 173-201A-070 provides that "existing beneficial uses shall be maintained and protected, and no further degradation which would interfere with or become injurious to existing beneficial uses shall be allowed." Of primary concern to King County's CSO control program are the water quality classifications for Puget Sound and outer Elliott Bay (class AA, extraordinary quality), inner Elliott Bay (class A, excellent quality), the Duwamish River (class B, good quality), and Lakes Union and Washington (lake class), since all King County CSOs discharge to one of those water bodies.

King County/Metro CSO History

When Metro assumed responsibility for wastewater management in 1958, very few effective treatment facilities existed. For the most part, wastewater was transported by sewers to the nearest waterbody for discharge to minimize human exposure and in the belief that discharging the wastewater within a larger body of water would neutralize any risk. In the 1960s, when Metro built interceptors to carry the wastewater to treatment plants instead of the waterbodies, a relief overflow was built into the connection between the raw sewage outfalls and the interceptors. As discussed previously, these are known as combined sewer overflows or CSOs.

By mid-1976 due to the passage of the Clean Water Act, joint planning was underway by the U.S. Environmental Protection Agency (EPA), the Washington State Department of Ecology, and Metro to develop, evaluate, and fund alternatives which would provide secondary treatment and CSO controls. In 1977, amendments to the Clean Water Act increased the amount of funding available through EPA for combined sewer overflow control projects. These amendments also provided for waivers from secondary treatment if receiving water quality could be adequately protected. It became apparent that the progress on planning for treatment facilities was going to be delayed significantly by requests for waivers. These developments eventually led to the segregation, in 1978, of the combined sewer overflow control elements from treatment-related decisions.

The *1979 CSO Control Program* identified a total of 30 projects to control CSO discharges to fresh water and marine waters. EPA had stipulated that grant money would be available only to those projects which could demonstrate a benefit justifying the cost of the project. The 30 projects were evaluated according to their benefit-to-cost ratio. That benefit-to-cost analysis was an important method of evaluating project proposals prior to 1986. Subsequent regulatory changes adopted performance standards, using volume control, then one event per year as a goal. As a result, later CSO control studies would place greater emphasis on whether a project could control CSOs to the levels specified in those regulations and less emphasis on costs versus marginal benefits.

During the early 1980s, considerable public attention focused on Puget Sound water quality and pollution issues, particularly contamination in urban bays. In May 1984, Metro issued the *Toxicant Pretreatment Planning Study Summary Report*, which described toxicant problems in Elliott Bay and other bays and raised concerns about CSO impacts on sediment quality at discharge sites. That same year, the Department of Ecology introduced legislation requiring all municipalities with CSOs to develop plans for "the greatest reasonable reduction (of CSOs) at the earliest possible date." A copy of this code can be found in Appendix A.

In order to comply with the Department of Ecology legislation, Metro produced two documents: the *1985 Final Plan for Combined Sewer Overflow Control (1985 Plan)* and the *1986 Final Supplemental Plan for Combined Sewer Overflow Control (1986 Final Supplement)*. Each of these documents were part of a five volume *Plan for Secondary Treatment Facilities and Combined Sewer Overflow Control,* which explored four alternative plans for secondary treatment and associated plans for varying reductions in CSO volumes.

The *1986 Final Supplement* was prepared in response to the agreement between Metro and the City of Seattle to evaluate a fifth secondary treatment configuration: the relocation of the West Point plant to a non-shoreline location. The supplement presented additional CSO controls which would accompany this fifth alternative. In addition, Metro evaluated CSO control projects which would achieve 75 and 90 percent volume reductions for all five secondary treatment configurations and included the results of upgraded computer modeling of the system.

In January 1987, before the *1985 Plan* could be implemented, the Department of Ecology published a new regulation on CSO control. The regulation (WAC 173-245) defined the "greatest reasonable reduction" in CSO volumes as "control of each CSO such that an average of one untreated discharge may occur per year." The regulation further required that each community submit, by 1988, a CSO plan specifying the means of complying with the new CSO control level. The regulation also required that updates on the progress of the plan be produced with NPDES renewals which occur at least every five years. Metro worked with the Department of Ecology to develop an interim goal of achieving a 75 percent CSO volume reduction systemwide by the end of the year 2005 and agreed to continue to work towards achieving the ultimate goal of one event per year. The revised plan, the *Final 1988 Combined Sewer Overflow Control Plan*, was submitted in April 1988. The plan describes CSO control projects that would be implemented to achieve the interim goal of 75 percent CSO volume reduction by the end of 2005. The plan also described additional projects that could achieve the ultimate goal of one CSO event per year.

An update for the *1988 Plan* was required in 1991, but Metro and the Department of Ecology agreed that the 1991 update would only include monitoring data and status reports on all scheduled projects because only one project had been completed since the *1988 Plan*. In addition, as required by the Washington Administrative Code, King County/Metro has prepared annual reports on the status of CSO projects and submitted them to the Department of Ecology yearly since 1988.

In 1993, Metro began work on its *Regional Wastewater Services Plan* (*RWSP*), a revision to its 1958 comprehensive sewer plan. This plan was meant to integrate long-range planning in all areas of wastewater services. Treatment and conveyance, biosolids reuse, CSO control, water reuse, and financing elements were included. The *RWSP* was intended to establish the priorities for all wastewater programs, including those that affect CSO controls.

While the *RWSP* process was occurring, King County (which had taken over Metro responsibilities with the merger of King County with Metro in 1994) developed its *1995 CSO Update* as required by Department of Ecology. The *1995 CSO Update* committed the agency to several new projects to provide one event per year control of CSOs. A Denny Way partial separation project from *1988 Plan* was changed in the *1995 CSO*

Update to a storage/treatment project to reduce the volume of Denny Way overflows by 50 percent with a one-event-per-year control element to be added later. The *1995 Update* also added an engineering study for the Henderson Street/Martin Luther King Way overflow to the long-term plan. A Harbor CSO pipeline project was added to take advantage of the additional storage that a larger West Seattle tunnel offered. The *1995 CSO Update* also scaled back its estimate of volume reduction that *1988 Plan* projects could achieve by 2005 from 75 percent to about 65 percent after improved modeling data showed CSO flows to be greater and the performance of the *1988 Plan* projects to be lower than the 1988 estimates.

In 1996, the Department of Ecology agreed that the interim 75 percent volume reduction goal would be dropped, as the *RWSP* was working towards the final goal of one event per year. Thus, the phasing of projects was re-prioritized so that the risk to public health posed by the existing discharges took priority over volume reduction.

In May 1997, King County released the draft *RWSP* for public comment. It contained four alternative wastewater service strategies, each with an associated CSO element that reduced CSOs to one discharge per year on average by 2040. After public comment and input from elected officials, government agencies, and other organizations, these service strategies were revised. In the spring of 1998, the King County *Executive's Preferred Plan* was released. The *Executive's Preferred Plan* called for construction of a new treatment plant in the north end of the King County service area. The plan also included a list of CSO control projects that would result in one-event-per-year control of all King County overflows by 2030. This Plan was revised by the King County Council and adopted by the Council at the end of 1999. Appendix C includes the CSO policies that were adopted.

Additional Requirements Impacting CSO Control Efforts

In addition to the state and federal regulations discussed previously, several other requirements also shape King County's CSO control efforts.

NOAA Settlement. In the late 1980s, King County and the City of Seattle were named as defendants in a lawsuit brought by the National Oceanic and Atmospheric Administration (NOAA) over natural resource damages in Elliott Bay and the Duwamish River that resulted CSOs and stormwater discharges. In a settlement agreement reached with NOAA in 1990, King County and the City of Seattle agreed to fund and to participate in an effort to clean up contaminated sediments and conduct habitat restoration projects.

City of Seattle Drainage Ordinance. Because of the hydraulic link between the two systems, the City of Seattle Drainage Ordinance could potentially reduce CSOs from both City and County systems over time. The ordinance requires that all new development (or redevelopment) of property within Seattle must discharge stormwater from the site to a storm sewer, or, if no storm sewer serves the property, the developer must provide stormwater detention so that peak flow from the site does not exceed 0.2 cubic feet per second per acre of impervious surface. The City's *1988 Combined Sewer Overflow Control Plan* was based in large part on the belief that, over time, as more and more of the city is redeveloped, a greater proportion of runoff from impervious area would be directed to storm drains or be detained by flow reduction or on-site storage projects installed by developers. The City of Seattle's own CSO control program is beginning to look at how the ordinance is being enforced and whether it has produced the kinds of reduced volumes anticipated in 1988.

Scope and Organization of this Update Report

This report provides an update of the CSO portion of the County's *Regional Wastewater Services Plan*. It has been organized into an Executive Summary and six chapters. A brief description of the contents of each chapter is provided below.

Executive Summary

The executive summary provides an overview of the *2000 CSO Update*.

Chapter 1. Introduction

The introductory chapter describes the CSO problem, discusses King County's CSO control history, and summarizes regulatory requirements and impacts on CSO control.

Chapter 2. King County's Conveyance System and CSO Control

Chapter 2 briefly describes King County's wastewater treatment and conveyance system and the County's relationship with the City of Seattle's CSO system. The chapter also includes information on King County's hydraulic modeling capabilities.

Chapter 3. King County's CSO Volume and Frequency

This chapter includes information on defining a CSO event, the three-hour versus 48-hour event interval, and the volume and frequency of CSO discharges under revised baseline conditions and as projected for 2005. The chapter also includes information on which King County CSO locations are controlled and are expected to be controlled by 2005, as well as a summary of CSO volume and frequency control for 1983, 1999, 2005, and 2030.

Chapter 4. The King County Existing CSO Control Program

Chapter 4 discusses the status of projects identified in the *1988 CSO Plan* and the *1995 CSO Update*, the projects to be completed in the next five years, and the progress made in other program elements.

Chapter 5. King County's Regional Wastewater Services Plan

This chapter briefly discusses the strategies included in the draft and final *Regional Wastewater Services Plan*, and a brief overview of environmental documentation of CSO control projects.

Chapter 6. New Regulations, Policies, and Initiatives Affecting the CSO Program

Since completion of the *1995 CSO Update* and the *RWSP*, a number of new regulations, policies, and initiatives have been adopted or enacted that may change the direction of CSO control planning in the future. Several of those policies are described, and their implications for King County's CSO program are explored. The chapter also includes some information on several CSO control technologies the County may want to further explore in the future.

CHAPTER 2

CHAPTER 2
KING COUNTY'S CONVEYANCE SYSTEM AND CSO CONTROL

This chapter briefly describes the components of King County's wastewater conveyance system and the County's relationship with the City of Seattle's CSO system. The chapter also includes King County's definition of a CSO discharge and updated information on King County's computer modeling.

Wastewater Conveyance System Overview

King County's wastewater system is the largest in the Puget Sound region. The system includes two large regional treatment plants (one in City of Seattle and one in City of Renton), one small treatment plant on Vashon Island, and two CSO treatment plants (both in City of Seattle), over 255 miles of pipes, 22 regulator stations, 38 pump stations, and 37 CSO locations (see Figure 2-1). After treatment and disinfection, treated effluent is discharged to Puget Sound for all five treatment facilities.

The King County wastewater service area consists of two sections, roughly separated by Lake Washington, as well as Vashon Island. The area east of Lake Washington receives wastewater flows from more than 122,000 acres that lie mostly east and south of Lake Washington. Development within this area was originally constructed with separate sanitary and storm sewers. Combined sewers and associated CSO control structures lie within the City of Seattle. The area west of Lake Washington receives a mixture of separated flows from north of Lake Washington and combined sewage from the City of Seattle. Sanitary and combined flows from the West Section are merged prior to arriving at the West Treatment Plant in Seattle. The City of Seattle is approximately 55,000 acres of which approximately 42,000 acres is combined. Figure 2-2 shows combined, partially separated, and separated areas (e.g., sanitary sewers and stormwater sewers) within Seattle.

The computer augmented treatment and disposal (CATAD) system is an important component of the wastewater conveyance system. The CATAD system has the ability to monitor and control King County's various pump and regulator stations. Water levels, gate positions, tide levels, and pump speed data are collected from monitoring locations throughout the system and transmitted to the main control center at the West Treatment Plant. A computer program uses this information to calculate flows, including overflows, from each regulator and pump station.

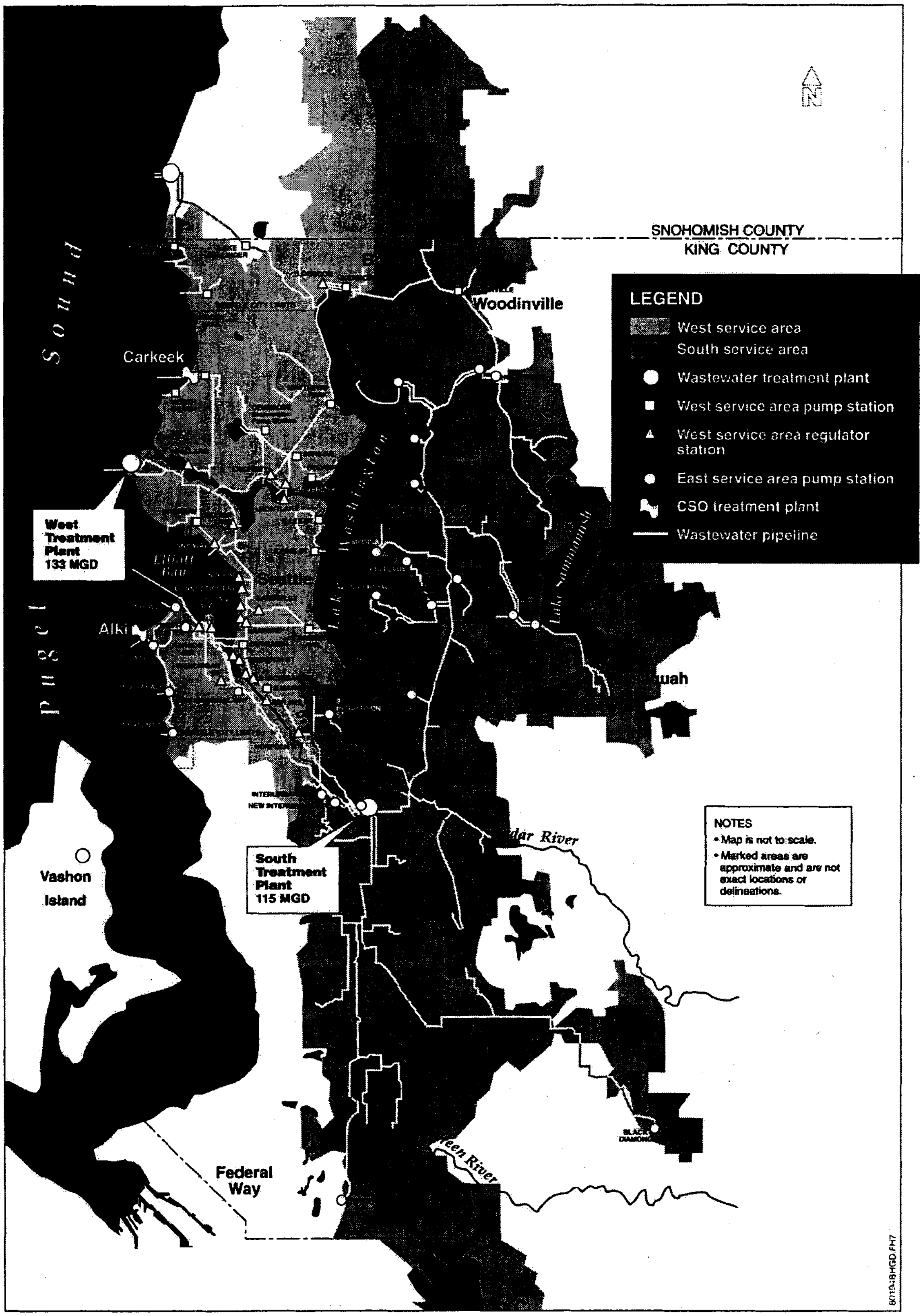

Figure 2-1: King County Wastewater Service Area

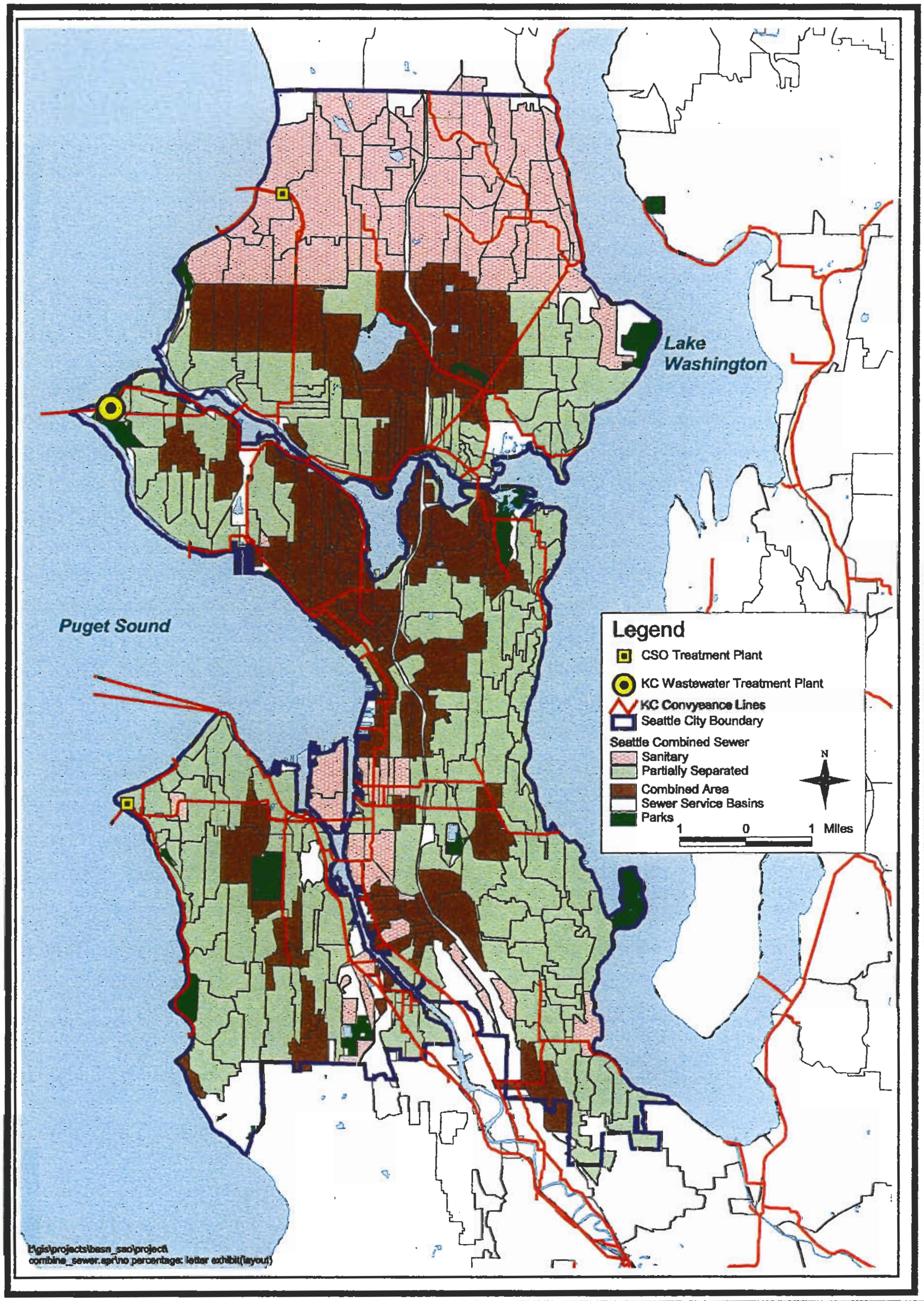

Figure 2-2: Percentage of Combined Sewer

Relationship between King County/Metro and City of Seattle Wastewater Systems

Metro was first formed as a metropolitan municipal corporation ("The Municipality of Metropolitan Seattle") in 1958 to clean up the waters of Lake Washington and the Seattle waterfront. In 1962, the City of Seattle transferred ownership of its treatment plants and portions of its sewer system to Metro, and Metro's monthly service charge went into effect. In 1993, voters in King County voted to merge Metro with King County and the merger took effect on January 1, 1994. Metro ceased to exist as a separate entity as of that date. Likewise, the Metro Council was dissolved, and the King County Executive and Metropolitan King County Council assumed responsibility for wastewater treatment and bus transportation. Today, King County's Wastewater Treatment Division provides sewage treatment services to 32 cities and districts within and adjacent to King County. King County operates a "wholesale" business, providing sewage conveyance and treatment services to "retailers" such as Seattle, who in turn sell sewer services to area residents and businesses. Seattle and the other local agencies are responsible for maintaining their own sewer collection systems. Seattle is the largest of the 32 local agencies served by King County and the only one with a combined sewer system. In order to reduce CSOs in a more efficient manner, the City of Seattle and King County have worked together on some wastewater system improvements.

Within the City of Seattle, there are over 140 CSO locations. When Metro was formed in 1958, pipelines, trunks, and interceptor sewers were generally assigned to Metro where facilities drained a basin of more than 1,000 acres. Metro also assumed ownership of treatment plants and some pump stations, regulators, and more than 30 combined sewer outfalls previously operated by the City of Seattle. The City was left with the other CSO locations and a sewer collection system serving roughly equal amounts of separated, partially-separated, and combined areas. The City pipelines collect sewage from throughout its service area and convey it to a King County trunk sewer or interceptors. Because it drains small basins, the City's system consists of smaller pipes than King County's conveyance system, which moves large amounts of wastewater from large drainage basins.

When storms occur, combined wastewater from both City and County pipes can discharge at the CSOs shown on Figure 2-3. Because City drainage basins are smaller, the overflows from the Seattle system are usually smaller in volume and shorter in duration than the overflows from the King County system.

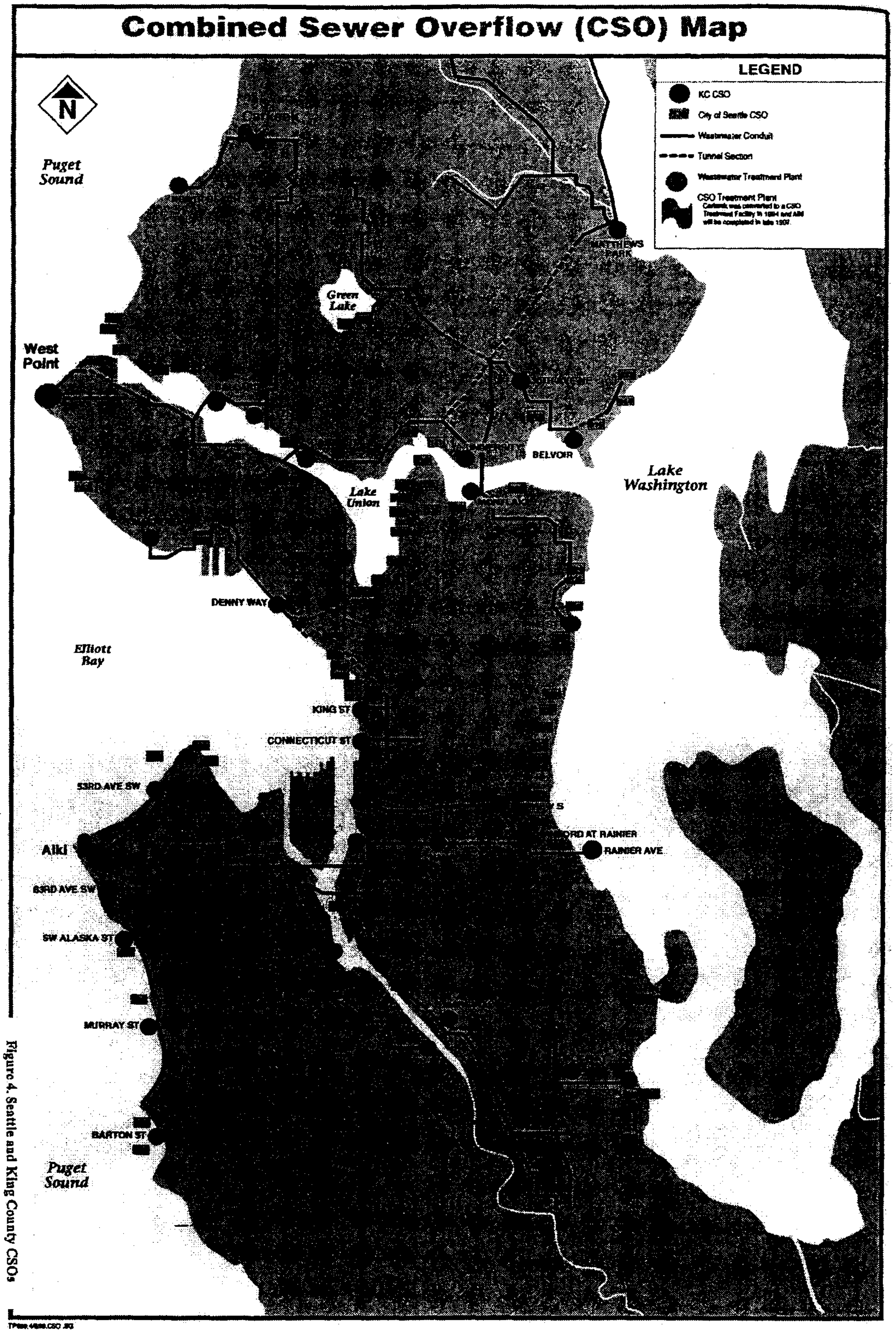

Figure 4. Seattle and King County CSOs

Figure 2-3: Combined Sewer Overflow Locations

King County's Computer Model of the Wastewater System

Computer models are used to developing simulations of wastewater flow and stormwater contributions in the wastewater system. These simulations, combined with calibrations/adjustments with field data and best engineering judgment, are used to predict the behavior of the wastewater system under different storm and sanitary flow conditions. The computer model is not a static model. With improvements in the science of computer simulations (new calculations and variables are added into the model to account for more of the factors that impact the system) and as more field data is collected over time, the model's input is revised and projections change. Changes in the model and projections represent more complete understanding of the system and should be expected over time.

Over the past 30 years, several different models have been used to analyze and predict the flow of wastewater and stormwater into and within the system. The following table provides an overview of the models used and some information on the models' capabilities. For more detailed information, see Appendix B.

CATAD

The Computer Augmented Treatment and Disposal system (CATAD) is a computer control system that is used to route and store wastewater flow within the wastewater system. CATAD is continually modified to take into account advances in computer modeling as well as inputs of more recent field data. Since 1991, CATAD (which includes the Predictive Control Program) has been modified to include the following components:

1) Raising storage levels behind regulator stations
2) Lowering the wet well level at Interbay Pumping Station when rainfall was detected upstream, moving flow to the West Point Treatment Plant sooner and vacating storage space in the interceptor
3) Incorporating the Predictive Control Program which monitors rainfall and conditions in the major trunks and interceptors, predicts inflows to the sewer system, and optimizes the regulation of flow through the regulators to minimize CSOs.

When implemented and operating together as designed, the three components have been estimated to reduce CSO volumes by 150 million gallons per year. All three components have been completed. However, problems at Interbay Pump Station and with the computer hardware at the West Treatment Plant have prevented the use of the second and third (Predictive Control) components. Improvements to the Interbay Pump Station are underway to ensure consistent successful operation of the pump station in "CSO mode" (lowering the wet well operating level) during storm events without entraining air into the pumps. Computer hardware and system software upgrades are being scheduled at the West Treatment Plant, which will enable operation of the Predictive Control Program. Modifications to the Predictive Control Program will be continually needed to incorporate new flow transfers and CSOs projects and to improve the efficiency and robustness of the optimization program.

Table 2-1: Description of Models used for Metro/King County CSO Planning

	Models		Brief Description of Capabilities
Decade	**Hydrologic** (surface runoff and local system flows)	**Hydraulic** (Metro/KC trunks and interceptor flow)	
1970s	**HYDRO**		Used synthetic unit hydrograph method for runoff due to rainfall from 58 NSA basins and 62 SSA basins.
		NETWORK	Used kinematic wave approximation for simulating flow through Metro trunks and interceptors.
1980s	**LCHYD**		Used diurnal base flow and constant infiltration to generate hydrographs from separated areas. Linear rainfall/inflow relationship.
	HYDRO72		Used synthetic unit hydrograph method for 19 basins in NSA.
	HYD72		Used synthetic unit hydrograph method for 62 basins in SSA.
		LCPRE	Lagged the hydrographs from LCHYD to put into SACRO.
		SACRO	A mass balance model that simulated flow through the NSA. (Kept track of flow but didn't solve hydraulic equations for levels.)
		SSACRO	A mass balance model that simulated flow through the SSA.
		EBIPRE	Lagged the hydrographs from HYD72 to put into SSACRO.
		SACE	Estimated total system overflows based on rainfall only.
1990s—2000s	**RUNOFF**		Kinematic wave simulation of runoff due to rainfall from > 400 basins. Variable inflow and infiltration based on rainfall and soil conditions. A physically based model.
		UNSTDY	A fully dynamic simulation of flow through King County trunks and interceptors. Computes flows, depths, and velocities in all pipes in the system. Simulates backwater effects, flow reversals, gravity waves, surcharges, etc. Simulates automatic operation of regulator and outfall gates and pump stations. Also, simulates Predictive Control, a computer program that controls the regulator gates to optimize the use of in-line storage. Used seven design storms in early 90s to estimate annual overflows. Now continuous 11-year simulations are run to estimate annual averages.

NSA = Northern Service Area (North of the Ship Canal)
SSA = Southern Service Area (South of the Ship Canal)

CHAPTER 3

CHAPTER 3
KING COUNTY'S
CSO VOLUME AND FREQUENCY

This chapter includes information on defining a CSO event, the three-hour versus 48-hour event interval, and the volume and frequency of CSO discharges under revised baseline conditions and as projected for 2005. The chapter also includes information regarding which King County CSO locations are controlled and are expected to be controlled by 2005 as well as a summary of CSO volume and frequency control for 1983, 1999, 2005, and 2030.

Overflow Event Definition

Rainstorms that are considered typical vary across the United States. Throughout much of the country, a storm generally consists of a short period of rainfall, followed by a longer dry period. In the Pacific Northwest, however, storms frequently follow a different pattern. Local storms may range from a constant drizzle, to a steady downpour, to a series of rainfall bursts separated by a few hours of dry, windy weather. In addition, rainfall duration and intensity can be substantially different in different areas of the same city. Thus, defining the beginning and the ending of a storm within the Puget Sound region can be very difficult.

As discussed previously, in a combined system, if the intensity of the rainfall is great or of a long duration, then overflows may result. These overflows may subside or cease entirely as the intensity of rainfall diminishes and capacity becomes available within the system. If the rainfall intensity increases later in the storm, the conveyance system may again reach capacity, and the overflow may resume.

The Washington State Department of Ecology regulations limit the frequency of overflow events to "an average of not more than one untreated discharge per outfall per year." However, Ecology regulations do not indicate how discharges are to be segregated and counted, nor do the regulations define overflow events. A CSO event can only occur due to capacity of the system being exceeded due to rainfall. Thus, a single rainfall event should produce no more than one CSO event.

Overflow events must be defined by a period without discharge between overflows. If a zero discharge period is less than a specified minimum, then the occurrences on either side of the dry period are considered to constitute parts of a single overflow. A zero discharge period equal to or longer than the specified minimum indicates that one overflow or CSO event has ended and a second has begun. Specifying a minimum duration for the inter-event period allows the segregation and counting of discharges at a CSO location.

In the *1988 CSO Plan*, Metro chose a three-hour period of no overflow (the inter-event interval) to define CSO events. As data was assessed over the years and the County saw multiple small overflow events being counted from single storms, the County began to question that definition as well as look more closely at how the wastewater system operates under storm conditions. It was found that to maximize the amount of wastewater flow within the pipes to convey the flow to a treatment plant, the regulator gates at CSO locations may open and close several times during a single large storm. In addition, since storms vary in intensity and duration across the service area, the County directed Brown and Caldwell in 1996 to correlate overflows and rainfall based on the premise that one rainfall event should result in only one overflow. An inter-event period of forty hours was found to provide a one-to-one correlation between rainstorms and overflows. The County chose a forty-eight hour inter-event period to simplify the calculations and to be consistent with the Ecology permit for the Carkeek CSO Treatment Plant. See the *CSO Event Definition Technical Memorandum*, attached as Appendix D to this report.

Between 1996 and this *2000 CSO Update*, the County has reported overflow frequency information based on both the three-hour and 48-hour intervals in its annual reports.

While using the 48-hour interval reduces the number of annual overflow events, it actually has little impact on the CSO capital facilities program because the size of the facilities needed to provide one-event-per-year control would not differ significantly. All the County's proposed CSO control projects are either CSO treatment or storage projects. For CSO treatment facilities, peak flow rate, not volume or the frequency of discharges, determines their size. Using 48 hours does not result in the treatment facilities being downsized. Storage projects could be reduced in size somewhat. If a storage project were to be designed to achieve one-event-per-year control at a particular outfall, the tank volume necessary to meet the regulatory requirement using a 48-hour inter-event period would be only about ten percent less than a tank designed using a three-hour interval. The County also found that the frequency count difference between the three-hour and 48-hour intervals was greatest when the CSO was least controlled, but that as the CSO moved toward control the difference between the two frequency estimates disappeared. Figure 3-2 shows the differences in the number of events using the three-hour and the 48-hour intervals over time. Beginning with this *2000 CSO Update*, the County will use the 48-hour inter-event period as its standard in measuring overflow frequency, as 48 hours accurately separates discharges into independent CSO events.

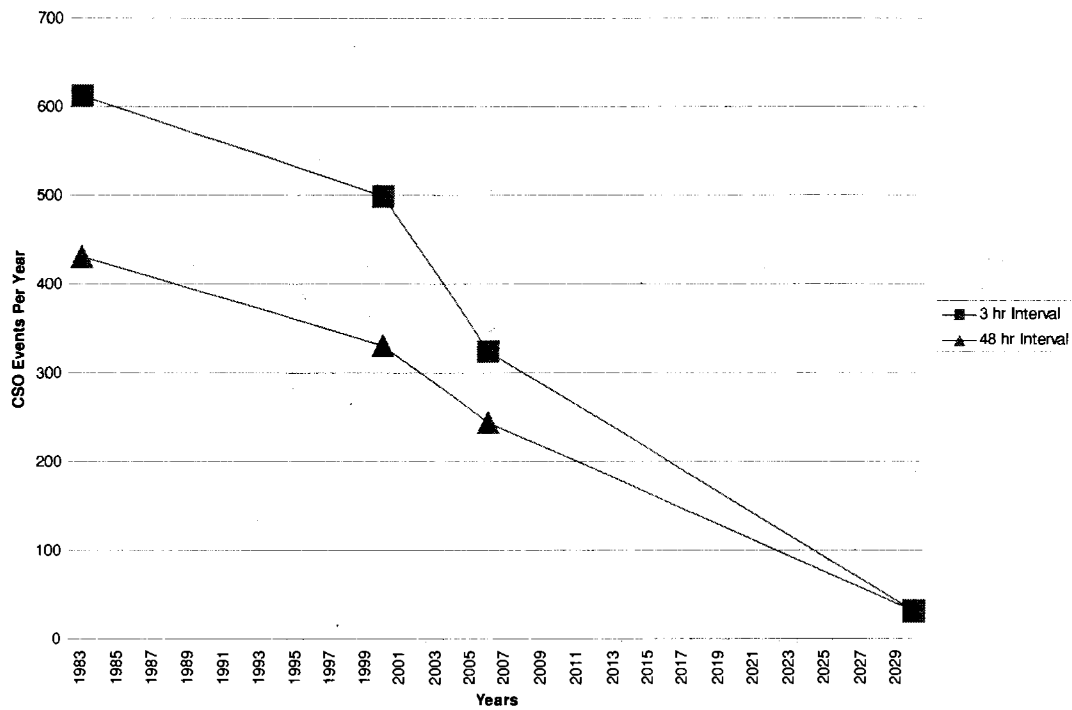

Figure 3-1: CSO Frequency Control Over Time
3-hour and 48 hour Inter-Event Interval

CSO Control Progress From 1983 to 2005

1983 Baseline

To assess progress, a baseline or benchmark of data is needed to compare past, present, and future conditions. The County chose 1981-83 conditions, simulated under near average rainfall, as its baseline or start for this formal phase of CSO control. When King County (then Metro) developed its second CSO Plan in 1988 the baseline used showed an average of 2.4 billion gallons of overflow occurring each year. Since then, new and refined versions of the model have been applied to the 1981-3 conditions and an updated baseline has been generated. Most recently, in 1999, the updated computer model recalculated overflows under 1981-83 conditions and found 2.3 billion gallons per year of overflow, nearly the same total as in 1988 but with significant differences at several of the individual CSO sites. The revised baseline is the benchmark for measuring progress in this *2000 CSO Update* and is included in Table 3-2.

1999 Conditions

1999 conditions (current conditions for this report) were simulated for 11 years. The rainfall data obtained was from actual rain gauges in the service area and therefore had a variety of rainfall types and durations. The average rainfall over the 11 years was close to the average annual rainfall volume in Seattle. The simulations indicate that an average of 1.5 billion gallons per year would overflow from the County system over an extended period under the existing system configurations and facilities. This is equal to a 34 percent volume reduction since 1983. Using the 48 hour inter-event interval, the model indicates that 11 of the 37 sites are controlled to the "one untreated event per year on average or less'' level (37 refers to actual discharge locations; some of the outfalls are shared). These sites include: Duwamish, Rainier, E. Marginal, Canal, Pine, Belvoir, 30th, Matthews, Alaska, 53rd, and 63rd. Table 3-1 shows controlled CSOs in 2000 and projected for 2005.

Table 3-1: CSOs Controlled in 2000 and 2005

Location	2000	2005
3rd Ave. W		
11th Ave. NW		
30th	X	X
53rd	X	X
63rd	X	X
8th Ave. + W. Marginal		
Alaska	X	X
Ballard		
Barton		
Belvoir	X	X
Brandon		
Canal	X	X
Chelan		
Connecticut		
Denny (Lake Union, Local, Interbay)		X
Dexter		
Duwamish PS	X	X
E. Marginal	X	X
Hanford (#1, Hanford at Rainier, Bayview N & S)		
Hanford #2		
Harbor		X
Henderson		X
King		
Lander #2		
Matthews	X	X
Michigan		
MLK		X
Montlake		
Murray		
Norfolk		X
North Beach		

Table 3-1: CSOs Controlled in 2000 and 2005		
Location	**2000**	**2005**
Pine	X	X
Rainier	X	X
S. Magnolia		
Terminal 115		
University		
W. Michigan		
Total Controlled	**11**	**16**

X= controlled

The Next NPDES Permit Cycle, 2001- 2005

The West Treatment Plant NPDES permit requires that this *2000 CSO Update* commit to projects for the next permit cycle. That cycle will begin January 2001 and is expected to run five years or through 2005. By that time, Denny Way/Lake Union CSO Control Project and the Henderson/Norfolk/Martin Luther King Way CSO Control Project will be completed. The system as it will exist after those two projects are operational was modeled to project anticipated CSO control progress to 2005. The model indicates that 0.96 billion gallons will remain to be controlled at that time, a 59 percent CSO volume reduction since 1983. Table 3-2 includes the volumes and frequencies for 1983 and 2005 as modeled in 1999.

Table 3-2: CSO Volume and Frequency: 1983, 1999, and 2005 (Based on historical CSO events and modeling done in 1999)								
Location	DSN[8]	Service Area	Volume Revised 81-3 Baseline Volume (MGY)	Revised 81-3 Baseline Frequency[4] (events/yr)	1999 Average Annual Volume (MGY)	1999 Average Annual Frequency[4] (events/yr)	2005 Average Annual Volume (MGY)	2005 Average Annual Frequency[4] (events/yr)
3rd Ave. W.	008	North	106	15	42	8	29	8
53rd Ave. SW	052	Alki	<1	<1	<1	<1	<1	<1
63rd Ave. [3]	054	Alki	10	2	1	1	1	1
8th Ave.		South	8	6	8	6	8	6
W. Marginal		South	0	<1	0	<1	0	<1
8th/W. Marginal Total	040	South	8	6	8	6	8	6
Alaska St.,SW (Beach Dr.)	055	Alki	<1	1	<1	1	<1	1
Alki Treated CSO [3]	051	Alki	na	na	52	4	52	4
11th Ave. NW (E Ballard)	004	North	5	14	18[5]	15	18	15
Ballard Reg.	003	North	90[6]	13	6[6]	8	6	8
Ballard Total		North	95	27	24	23	24	23
Barton	057	Alki	8	8	8	8	8	8
30th Ave. NE	049	North	<1	<1	<1	<1	<1	<1
Belvoir	012	North	<1	<1	<1	<1	<1	<1
Belvoir/30th Total			<1	<1	<1	1	<1	<1
Brandon St.	041	South	64	32	49	28	49	28
Carkeek Treated CSO	046	Carkeek	na	na	51	9	53	9
Canal St. (Lake City)	007	North	1	1	1	1	1	1
Chelan	036	South	61	7	32	7	32	7
Connecticut	029	South	90	23	79	10	70	10
Denny Way Lake Union		South	300	25	292	23	<1	1
Denny Way Local		South	94	21	72	19	<1	1
Interbay		South	108	15	85	10	8	1
Denny Treated		South	na	na	na	na	293	14
Denny Way Untreated Total	027	South	502	25	449[6]	24	8	1
Dexter	009	North	24	15	24	15	1	1
Duwamish P.S.	034	South	<1	<1	1	1	1	1
Bayview N.		South	na	na	5	4	5	4
Bayview S.		South	na	na	<1	<1	<1	<1
Hanford@Rainier		South	na	na	60	11	60	11
Hanford #1 Total	031	South	378	40	65	11	65	11
Hanford #2	032	South	266	23	210	15	223[7]	15
Hanford Total		South	644	63	275	26	288	26
Harbor Ave.	037	South	36	26	36	26	1	1

Table 3-2: CSO Volume and Frequency: 1983, 1999, and 2005
(Based on historical CSO events and modeling done in 1999)

Location	DSN[8]	Service Area	Volume Revised 81-3 Baseline Volume (MGY)	Revised 81-3 Baseline Frequency (4) (events/yr)	1999 Average Annual Volume (MGY)	1999 Average Annual Frequency (4) (events/yr)	2005 Average Annual Volume (MGY)	2005 Average Annual Frequency(4) (events/yr)
King Street	028	South	55	14	38	14	38	14
Lander	030	South	143	22	100	12	100	12
Magnolia, S	006	South	14	21	14	21	14	21
Marginal, E.	043	South	<1	<1	<1	<1	<1	<1
Matthews Park	018	North	<1	<1	<1	<1	<1	<1
Michigan	039	South	190	32	150	28	150	28
Michigan, W.	042	South	2	5	2	5	2	5
Montlake	014	North	32	5	32	5	32	5
Murray	056	Alki	6	5	6	5	6	5
Henderson	045	South	15	11	2	7	<1	<1
MLK Jr. Way	013	South	60	15	60	15	<1	<1
Norfolk Treated CSO	044	South	na	na	na	na	12	2
Norfolk Untreated CSO	044	South	39	18	5	4	1	1
North Beach	048	Carkeek	6	17	6	17	6	17
Pine, E St.	011	North	<1	<1	<1	<1	<1	<1
Rainier Ave.	033	South	<1	1	<1	1	<1	1
Terminal 115	038	South	2	3	2	3	2	3
University	015	North	126	12	90	10	90	8
TOTAL UNCONTROLLED			**2339**	**431**	**1536**	**331**	**961**	**245**

(1) Numbers are rounded.
(2) Shaded lines for information only; the volumes and frequencies on the shaded lines are not included in the totals.
(3) Plant outfall limited to 55 mgd.
(4) Based on 48 hour inter-event interval.
(5) The increase at 11th is due to the Carkeek transfer bringing more flow into that basin.
(6) The large decrease in volume reduction from 90 mgy to 6 mgy is due to the Fort Lawton Tunnel Project and pump station upgrade. Flow is sent to the Fort Lawton Tunnel instead of overflowing at the Ballard Regulator.
(7) 1999 decrease due to separation project offset some by population growth by 2005.
(8) DSN is the Discharge Serial Number, a unique identifier listed in the NPDES permit.

Complete CSO Control

In the first quarter of 2000, the CSO system was modeled to look at CSO remaining with the 2005 system (the same system as now but with Denny Way and Henderson/MLK Way/Norfolk CSO control projects operational), but under 2020 population projections (when the West system is at capacity). The 2020 peak overflow rates (for treatment projects) and annual storm volumes (for storage projects) were compared with those projected in the 1995 modeling for the *Regional Wastewater Services Plan* effort to identify if any of the *Regional Wastewater Services Plan* projects needed to be changed. Based on changes in projected overflow rates, projects needing reexamination include:

Connecticut, Brandon, King, 8th Ave. S., Hanford at Rainier, Hanford #2, Lander #2, Michigan, S. Magnolia, Ballard Regulator, Montlake, and University. None of these projects will begin during the next permit cycle so their reexamination will occur in the *2005 CSO Update*. One event per year overflow volumes were not projected, but were estimated to be 330 million gallons per year in a November 1994 study. Frequencies will be one untreated event per year at Denny and the storage projects, and approximately less than one untreated event per year at the rest of the treatment projects. This is a total CSO frequency of one event per year on average at 30 locations. The *Regional Wastewater Services Plan* includes a list of over 20 CSO control projects that will control CSOs to one untreated event per year on average by 2030 at each of the projects' CSO locations.

Summary of CSO Control

Actual and projected control progress over time is summarized in Table 3-3 and Figure 3-3.

Table 3-3: Summary—CSO Reduction Over Time (Modeled in 1999)

	1982-3 Baseline	1999	2005
Volume (MGY)	2338	1536	961
Frequency (Events /year with 48 hr interval) (1)	431	331	245

(1) This number includes untreated discharges.

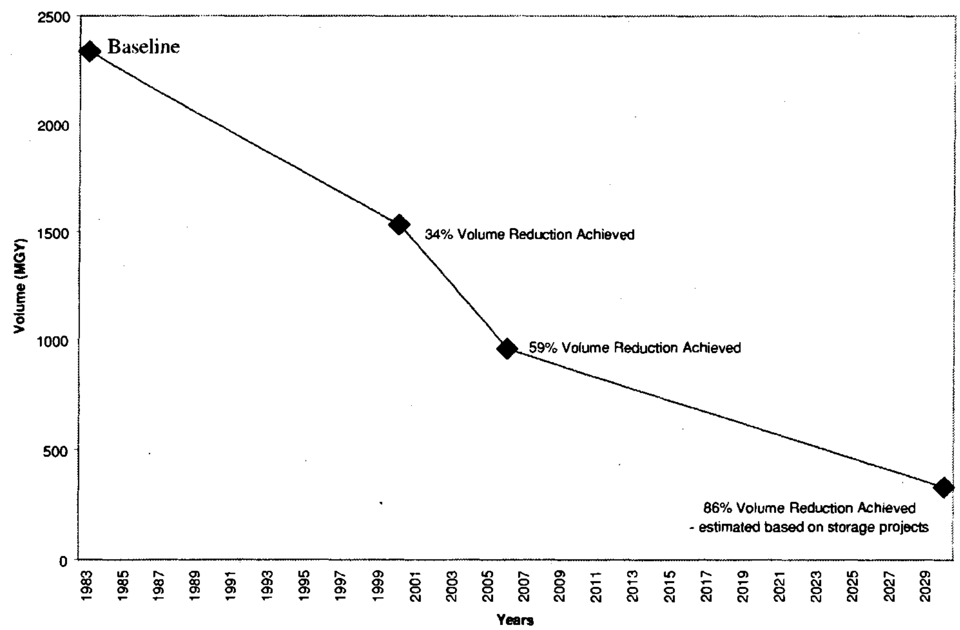

Figure 3.2: CSO Reduction Over Time

CHAPTER 4

CHAPTER 4
KING COUNTY'S
EXISTING CSO CONTROL
PROGRAM

This chapter discusses the status of projects identified in the *1988 CSO Plan* and the *1995 CSO Update*, as well as the status of existing and new program elements. This includes King County's CSO Posting and Notification Program, information on meeting EPA's Nine Minimum Controls, projects currently slated for construction over the next few years, and King County's continued coordination with City of Seattle.

Previous CSO Control Projects

The *1988 CSO Plan* identified a number of control projects to achieve the plan goal of 75 percent system-wide CSO volume reduction, and the *1995 CSO Update* reviewed progress on the CSO program since 1988 and added a few new projects to the program. Table 4-1 summarizes the projects discussed in each of those documents. An update on some of the projects listed in the table is provided in this chapter.

Alki Transfer/CSO Treatment Plant Project

In the 1980s to further centralize treatment at either West Treatment Plant in Seattle or the South Treatment Plant in Renton, King County/Metro agreed that the Alki primary treatment plant would be modified into a CSO treatment plant. This modification included several elements: the construction of the West Seattle Pump Station, the construction of the West Seattle Tunnel to convey base sanitary flows up to 18.9 million gallons to West Point (the "northern transfer), and the construction of pipelines to transfer equivalent flows from the southern part of the West service area to the South Treatment Plant via the Allentown trunk sewer and Interurban Pump Station to achieve a zero net effect on the Elliott Bay Interceptor (the "southern transfer"). The northern transfer was completed in 1998 and the southern transfer was completed and operating in March 1996). The West Seattle Tunnel is used for storing 3.5 million gallons from the Alki basin and will also be used to store 3.5 million gallons to handle the one-year storm from the Harbor Regulator to reduce the Harbor overflow to one event per year.

Flows above 18.9 million gallons per day and above the 3.5 million gallons of Alki basin storage are sent to the Alki CSO Treatment Plant. This occurs by the overtopping of weirs into the 63rd Avenue Pump Station when the Spokane Regulator Gate is closed. There is an additional 1.1 million gallon of storage available in the basins in the Alki Plant which can be used prior to discharge of treated flow into Puget Sound. If the flows are not going to exceed 1.1 million gallons, the stormwater flow is stored and returned to the tunnel for transport to the West Treatment Plant.

The 55 million gallons per day maximum discharge for the Alki CSO treatment plant is based on the tides. The discharge can vary from 46 million gallons per day to 55 million gallons per day.

Flows in excess of the 18.9 million gallons per day to the West Treatment Plant and above the 46 to 55 million gallon per day maximum discharge for the Alki Treatment Plant are overflowed at the 63rd Avenue Pump Station. The overflow is expected to occur approximately one time on average per year according to computer modeling.

Conversion of the Alki Plant to a CSO Treatment Plant included automatic operation and control to allow the plant to begin operation without human control; monitoring of functions by the South Treatment Plant; some automatic sampling of flow; a new control panel; internal pumping changes; change over of the gaseous chlorine system to a sodium hypoclorite system which serves the CSO Treatment Plant and the 63rd Avenue Pump Station; addition of caustic tanks for use in odor control; gates on each clarifier to control flow into the plant; and facilities to enable efficient cleaning of the plant after an event.

Harbor CSO Pipeline

The Harbor CSO Pipeline Project was constructed to convey overflows from the Harbor Regulator to the new West Seattle pump station for storage in the new West Seattle Tunnel, thereby controlling CSO at the Harbor Regulator to one event per year or less. This is a change from the *1988 CSO Plan* which recommended partial separation to control Harbor CSOs. The project was revised when County modeling indicated that partial separation would not control Harbor CSO to the one event per year level, requiring the addition of storage. The availability of nearby storage in the West Seattle Tunnel made the Harbor CSO Pipeline a cost-effective alternative.

The current Harbor project was re-prioritized to be completed sooner than scheduled in the *1988 CSO Plan* due to the cost and environmental benefits from constructing the pipeline concurrently with the Alki Project's West Seattle forcemain. The Harbor pipeline portion of the project enlarged the trench for the forcemain and laid a new 54-inch pipe underneath. The cost of the current Harbor project was much less than the cost of excavating a new pipeline and trench for the 54-inch pipe. Risk of affecting the integrity of the forcemain by future construction was also avoided. It is expected that by 2001 when the Alki Plant modications are complete and operating experience gained with the West Seattle Tunnel, that the Harbor CSO will be controlled to one untreated discharge per year.

Henderson/Martin Luther King Way Engineering Study

Henderson overflows were believed controlled in 1988, but subsequent modeling revealed that overflows still occur there. As a result, the County conducted an engineering evaluation and recommended a 3.2 million gallon storage/treatment facility near the Norfolk regulator to remedy the problem. Predesign work on the project began in 1997, and further evaluation at that stage indicated that a storage/treatment tunnel would be more cost effective than a tank and treatment facility. Construction of the new facilities to control Henderson, Martin Luther King Way, and Norfolk CSOs is part of the County's control plan for the next five years and is expected to begin in 2001 and be completed by 2004.

Denny Way/Lake Union CSO Control Project

The *1988 CSO Plan* Denny Way project was a partial separation project. The *1995 CSO Update* replaced that with a storage project that would reduce the annual volume of overflows from the Denny Way regulator station by about 50 percent. According to the *1995 CSO Update*, a second stage of the project, to reduce untreated discharges to one per year, was to be designed and constructed later. Predesign of the storage project began in 1996, and the design team concluded that it would be more cost effective to construct a single storage/treatment facility to meet the one discharge per year requirement now than to construct one project now and a second project later. As a result the Denny Way/Lake Union CSO Control Project described later in this chapter will constitute part of the County's CSO control program for the next five years.

Kingdome/Industrial Area Storage and Separation Project

Originally part of the *1988 CSO Plan*, a Kingdome/Industrial area partial separation project was to be completed by 2006. A predesign report for the project, including five different combinations of separation and associated storage, was completed in 1991. The predesign recommended immediate completion of a new 96-inch diameter trunk sewer from Airport Way to Alaskan Way to coincide with a street widening project planned by the Washington Department of Transportation and the City of Seattle. About half the length of the pipeline (about 1,500 feet) was constructed in 1994 to take advantage of other improvements and was used as storage.

In 1997, the Washington Public Facilities District (PFD) began construction of a new baseball park at the corner of First Avenue South and South Royal Brougham Way. In connection with ball park construction and so that the ball park would have a place to discharge its stormwater, the PFD connected the east end of the 96-inch trunk line to the 72 inch stormline, thus allowing the old 72-inch combined sewer between Third Avenue South and the waterfront to be converted to use as a stormwater drain. The PFD.also constructed an overflow structure at the west end of the 96 inch pipe. As a result, approximately 75 acres of the Kingdome/Industrial area has now been effectively separated.

The *RWSP* calls for construction of a storage and treatment facility that would control combined King and Connecticut Street overflows. The storage/treatment project has been deferred until 2026 because other projects would control discharges to areas with greater recreational and human contact uses than the lower Duwamish River. During the course of this *2000 CSO Update*, the project team looked at accelerating the

King/Connecticut project because of the redevelopment in the area that followed the completion of the baseball stadium and construction of a new exhibition hall (completed November 1999) and football stadium (to be completed 2003). The City of Seattle CSO program did not support further separation in the area.[1] The project team concluded that while there was some potential to increase the project's cost effectiveness by coordinating with an upcoming highway project planned for the area, the potential cost savings did not justify deviating from the County project prioritization established in the *RWSP*.

Michigan Street Separation Project

The *1988 Plan* called for completion of a Michigan Street separation project by 2005. Upon revisiting the project during its *RWSP* work, the County concluded that construction of a storage and on-site treatment facility would be more cost effective. Furthermore, because the public health benefits from CSO control are believed to be greater along Puget Sound beaches and the east end of the Lake Washington Ship Canal, the Michigan project has been deferred to 2022.

Brandon Separation Project

During the predesign on the Michigan separation project, the predesign team recommended that a partial separation and storage project at Brandon Street be added to the list of proposed projects. Subsequently, the *RWSP* team concluded that at-site CSO treatment done jointly with flows from the Michigan Street CSO would likely be more cost effective. A Michigan/Brandon storage/treatment project has been scheduled for completion in 2022 under the *RWSP*.

North Beach Pump Station Upgrade and Storage Project

At the time of the *1988 CSO Plan*, overflows from the North Beach pump station were thought to be controlled. However, during the design of the Carkeek CSO treatment plant, planners learned that overflows continued at North Beach. A predesign of a North Beach control project was initiated in 1993. As a result, the *1995 CSO Update* proposed a pump station upgrade, including a storage basin at the pump station site and a new pipeline. The *1995 CSO Update* called for timing of the project to be determined as part of the *RWSP*. The *RWSP* has scheduled the project for completion in 2011. This project is also being re-evaluated in light of a study being undertaken on the Carkeek CSO Treatment Plant. Due to re-evaluation, the project may need to follow a different schedule than that included in the *RWSP*.

[1] However, any new development or redevelopment in the area would be subjected to the City's drainage ordinance which requires storm water be routed to street storm drains or that on-site detention be provided.

Table 4-1: CSO Control Projects Under CSO Plans and CSO Updates		
Plan	**Proposed Projects**	**Status as of 4/2000**
1988 CSO Plan		
Phase 1 (1987-1991)	• Hanford Separation • Bayview Storage • CATAD Modifications	Completed Completed On-going
Phase 2 (1992-1997)	• Fort Lawton Parallel Tunnel • University Regulator (Densmore Diversion) • Carkeek Transfer/CSO Treatment Plant • Lander Separation • Alki Transfer/CSO Treatment Plant	Completed Completed Completed Completed Completed Completed
Phase 3 (1995-1999)	• Denny Way Partial Separation • Diagonal Separation	Delayed and revised under later CSO updates Determined to be a City of Seattle Project
Phase 4 (2000-2005)	• Michigan Street Separation • Kingdome/Industrial Area Storage and Separation	Delayed and revised under later documents Revised under later documents
1995 CSO Update		
	• Denny Way/Lake Union CSO Control Project • Henderson/MLK Way Engineering Study • Harbor CSO Pipeline • Brandon Separation • North Beach Storage and Pump Station Upgrade	Design Completed Completed[1] Revised under *RWSP* Reprioritized under *RWSP*
1999 RWSP		
	• 21 CSO projects proposed	To be completed between 2010 and 2030
2000 CSO Update		
	• Denny Way/Lake Union CSO Control Project • Harbor CSO Pipeline Project • Henderson/MLK Way/Norfolk Project	Construction to be completed in 2004 Completed[1] Construction to be completed in 2004.

[1] This project was completed, but not used while the West Seattle tunnel operation is being fine-tuned. The project will be activated for the 2000-01 wet season.

Existing CSO Program Elements

Since the development of the *1995 CSO Update*, King County has developed and/or completed several program elements and planning documents. These include water and sediment quality monitoring, developing a CSO Posting and Notification Program, designing two major CSO reduction projects, coordinating with City of Seattle CSO Programming, developing a Sediment Management Plan, and undertaking a CSO Water Quality Assessment (the last two are discussed in the next chapter).

Water and Sediment Quality Monitoring

In order to comply with WAC 173-245-040(2) and the West Point Treatment Plant NPDES permit requirements, a CSO reduction plan must include a characterization of CSO discharges based on flow monitoring and sampling of CSOs. As described in the *1988 CSO Plan*, Metro was to sample overflows from five sites per year and sediment off of nine outfalls in an effort to characterize CSO discharges and the affected offshore sediments. Sampling was determined to be complete in 1995.

In addition to the CSO monitoring requirement, the West Point NPDES permit also required sediment monitoring. A baseline sediment monitoring plan was submitted to Ecology in October 1994. The plan provided for monitoring of marine sediments in the vicinity of wastewater plant outfalls and remaining CSOs. Sediment monitoring was required at ten CSO sites in the Seattle area, including Hanford Street, Connecticut Street, Chelan Avenue, South Magnolia, 53rd Avenue SW, North Beach, SW Alaska Street, SW Murray Street, SW Barton Street, and 63rd Avenue SW. Sediment sampling was completed in 1997, meeting NPDES requirements.

Nine Minimum Controls Related Activities

King County has implemented a number of programs to satisfy the requirements of the Nine Minimum Controls, which are a part of EPA's CSO Control Policy. Those programs are summarized in Table 4-2. Ecology noted the need for additional documentation or work on controls 6, 7, and 8 in the 1996 West Treatment Plant (West Point) NPDES permit. Specific programs that meet the requirements for those three controls are more fully described in Table 4-2.

Table 4-2: King County's Compliance with EPA's Nine Minimum Controls

Nine Minimum Controls	King County Compliance Effort
1. Proper operation and regular maintenance programs for the sewer system and CSOs	King County regularly maintains CSO outfalls, regulators, and pump stations through the West Treatment Plant, South Treatment Plant, and collection system maintenance divisions. Proper facility operation is managed by West Point staff using CATAD. Collection system staff inspect sewers on a specified schedule and perform corrective action when deficiencies are found. Maintenance schedules and records are available for inspection upon request.
2. Maximize use of collection system for storage	CATAD manages regulator stations to maximize flows in interceptors and store excess flows in large trunk sewers.
3. Review and modification of	King County's Industrial Waste Program issues permits that set limits on the chemical contents of industrial discharges. The

Table 4-2: King County's Compliance with EPA's Nine Minimum Controls	
Nine Minimum Controls	**King County Compliance Effort**
pretreatment requirements to ensure that CSO impacts are minimized	program also includes monitoring and permit enforcement, education and technical assistance to businesses on appropriate waste pretreatment and disposal techniques. King County also helps fund the Local Hazardous Waste Management Plan. Current water quality assessment and sediment management plan data indicate no need for CSO specific pre-treatment program modifications.
4. Maximization of flow to secondary treatment plant for treatment	CATAD is used to maximize flow to the West Treatment Plant by operation of regulator and pump stations. All analysis for CSO control project alternatives include varying levels of storage and transfer to the secondary treatment plants.
5. Elimination of CSOs during dry weather	King County's maintenance and operations are directed at preventing dry weather overflows. Dry weather overflows may occur as a result of equipment malfunction or loss of power. The conveyance system is monitored through CATAD, and corrective action is taken immediately if a problem occurs. Equipment problems are immediately reviewed, and repair or replacement activity is undertaken in a timely manner. Dry weather overflows are reported to Ecology as sanitary sewer overflows.
6. Control of solid and floatable materials in CSOs	City of Seattle street sweeping and catch basin maintenance limit introduction of floatable materials to sewers.
7. Pollution prevention programs to reduce contaminants in CSOs	King County has implemented both the Industrial Waste Program and the Local Hazardous Waste Management Program to reduce discharge of chemicals and other substances that negatively impact the environment and the wastewater treatment process.
8. Public notification program to ensure that public receives adequate notice of CSO events and impacts	As a joint project with the City of Seattle and the Seattle King County Health Department, King County has developed a CSO Posting and Notification Program. This program includes posting signs at publicly accessible CSO locations, an information line, web site, brochure, telephone hotline, and other public outreach aspects.
9. Monitoring to effectively characterize CSO impacts and the efficacy of CSO controls	Under the *1988 CSO Plan*, KingCounty's sampling program (now complete) included collecting data for five CSO sites per year. The King County 1999 *CSO Water Quality Assessment* found that majority of risks to people, wildlife, and aquatic life would not be reduced by removal of CSOs because most risk-related chemicals come from sources other than CSOs. King County may undertake additional sampling upon completion of specific CSO control projects.

Pollution Prevention Programs

The seventh of the Nine Minimum Controls, pollution prevention, is intended to keep contaminants from entering the sewer system and discharging to receiving water in

CSOs. Pollution prevention is aimed at controlling pollution at its source, before it is produced and before it enters storm runoff or surface waters. The focus is on changing people's behaviors rather than building new facilities.

King County pollution prevention efforts include the following programs:

- ***Industrial Waste Program.*** King County's Industrial Waste Program administers the County's industrial waste regulations for local businesses that discharge industrial wastewater to the County's sewer system. The Industrial Waste group applies the same program to both combined and separated areas. Program activities include administration of waste discharge permits, inspections, enforcement, sample collection to determine compliance, and collection of surcharge and monitoring fees. The Industrial Waste Program routinely conducts monitoring throughout the County to trace discharges that could harm workers or disrupt treatment plant operations. Industrial Waste staff members also work with businesses to help them identify and employ pollution prevention practices.

  King County issues several types of discharge approvals, including permits, discharge authorizations, discharge letters, and verbal approvals. Approvals vary depending upon the volume and characteristics of the discharge. A permit is required for discharges of more than 25,000 gallons per day or for federally regulated industries.

  King County establishes local limits to ensure the wastewater treatment processes are not compromised by industrial discharges; specific industries are subject to federal pretreatment requirements that can be more stringent than local requirements.

- ***Local Hazardous Waste Management Program.*** King County's Wastewater Treatment Division funds 17 percent of the King County Local Hazardous Waste Program and administers the program. The goal of the program is to reduce the quantities of hazardous waste generated by households and small businesses and to divert these wastes from municipal waste streams and indiscriminate disposal in the environment. Program services include household hazardous waste education and collection; small business education, technical assistance, and compliance assistance; small quantity generator collection and waste handling; an industrial materials exchange; and a hazardous waste library.

Best Management Practices (BMPs) include source controls that can be installed in the existing sewer system at catch basins with little construction. BMPs are focused on litter control, but collect some sediments and grit. Types of BMPs researched include street sweeping, catch basin modifications to install gas hoods, baffles, catch basin inserts, and curb inlet closures. Effectiveness of these technologies is increased with frequent cleaning and maintenance. Most BMPs are not available to King County because streets and catch basins are owned and operated by the City of Seattle. These technologies are used in Seattle's program and contribute to overall floatables capture in the system. Literature on similar programs indicates capture of as much as 85 percent.

Control of Solid and Floatable Materials in CSOs

The control of solid and floatable materials in CSOs is aimed at reducing visible floatable materials and solids using relatively simple measures. There is no quantitative standard for floatables control, and King County has had few complaints concerning materials floating or washing ashore near CSO outfalls during discharges. Nevertheless, the County is taking steps to insure that discharge of floatable materials does not become a problem.

As part of this *2000 CSO Update*, King County has investigated devices such as baffles, weirs, and screens that can be used at each overflow location to remove coarse solids and floatables before discharge. Certain floatables control technologies, such as underflow baffles and screens, show promise of providing cost-effective floatables control. Underflow baffles are vertical plates that extend from the top of a sewer chamber to below the top of a nearby overflow weir. Highly buoyant floatables are retained behind the baffle and then conveyed to a downstream facility by dry-weather flow or the floatables can be retained by a facility constructed at the overflow site. Screens include horizontal, vertical, and semi-circular screens with coarse or fine bar spacing. Screens may be manually cleaned or some have mechanical cleaning rakes or brushes. Screens can be placed in-line or at the end of the outfall pipe and they remove particles typically larger than their smallest opening. Screened material must either be removed or flushed for treatment downstream. King County has included floatable control facilities, including underflow baffles and screens, in recent construction or design projects.

As discussed previously, City of Seattle floatables control includes best management practices (BMP). Further improvements may be desirable in specific circumstances, the literature indicates that the improvement to be gained by further modifications of the system may be minimal on the whole.

Joint Posting and Public Notification Program

From fall 1998 to spring 1999, the County worked with the City of Seattle and the Seattle/King County Department of Public Health to develop a joint CSO posting and public notification program. Under this program, signs have been erected near CSO outfalls (see Figure 4-1 for an example), a public outreach effort, a media release, a brochure, a fact sheet, a website, and a CSO information telephone number have all been developed. The program is aimed at informing the public about the location of CSOs, their actual occurrence, and the possible health or environmental impacts of CSOs.

Figure 4-1: CSO Outfall Warning Sign

King County CSO Project Coordination with City of Seattle

As discussed in Chapter 2, City of Seattle and King County's wastewater system are interconnected—CSOs of both agencies are located within the City of Seattle, local wastewater pipes from the City tie directly into major interceptors of the King County system, some of the City's stormwater connections tie directly into the sewer system (e.g., combined sewers), and the two agencies work to reduce CSOs by sharing any excess storage capacity existing within the system when needed.

To meet the challenge of reducing CSOs, Seattle and King County have coordinated projects. Past projects include:

- Seattle Forward Thrust Sewer Separation
- Hanford Separation
- Lander Separation

Present projects include:

- Denny Way/Lake Union CSO Control Project
- CSO Posting and Notification Program
- Carkeek Overflow Reduction Study
- Elliott Bay/Duwamish Restoration Panel predesign of a possible Duwamish-Diagonal Sediment Clean-Up Project

and both agencies continue to work together in sharing computer modeling and Geographic Information Services data, sharing information on alternative CSO Control technologies, and participating in each other's consultant selections. For future CSO reduction efforts, discussion has included sharing data from flow monitors, placing monitors to be useful for both agencies (and avoid duplication of efforts and costly equipment), undertaking sediment clean-up projects, and undertaking an inventory of the connections between the two systems as well as connection agreements.

King County CSO Control Projects Through 2005

King County CSO control efforts over the next five years will center on two major construction projects: the Denny Way/Lake Union CSO Control Project and the Henderson/Martin Luther King Way CSO Control Project. Those two projects are summarized below.

Denny Way/Lake Union CSO Control Project

The Denny Way/Lake Union CSO Control Project is a joint effort of King County and the City of Seattle to control City overflows to Lake Union and County overflows to Lake Union at Dexter and Elliott Bay at the Denny Way regulator station. Historically, Denny Way has been the largest CSO in the King County system, discharging an average of more than 500 million gallons of combined wastewater annually.

The project to control Denny Way CSOs was divided into phases. In 1997, the City completed construction of Phase 1, a pipeline along the east and south shore of Lake Union to gather flows that discharge there. The City's Phase 2 project will connect that pipeline to the County's Phase 3/4 facilities.

As described in the *1995 CSO Update*, Phase 3 was originally conceived as a project to reduce discharge volume by 50 percent at the Denny Way CSO. Phase 4 was to be a future project to limit untreated discharges to one per year. During the early stages of Phase 3 design, the County found that combining storage and at-site treatment into a single project would be more cost-effective than constructing two separate projects. The resulting Phase 3/4 project will control Lake Union and Denny Way CSOs by storing CSO flows during a moderate storm and transferring them to the West Treatment Plant after the storm subsides. During larger storms, the facilities will provide primary treatment in the tunnel, screening for floatable control, disinfection and dechlorination, at the Elliott West site before discharging the treated effluent to Elliott Bay. Required facilities include:

- **Mercer tunnel.** A treatment/storage tunnel, 6,200 feet long and 14-feet, 8 inches in diameter, under Mercer Street between Dexter Avenue North and Elliott Avenue West will provide 7.2 million gallons of CSO storage and primary sedimentation. The tunnel will also convey flows to new CSO control facilities at Elliott West.
- **Elliott West CSO facility.** A new CSO treatment plant at the Elliott West site will include floatables removal, disinfection, and dechlorination facilities.

- **Elliott West pipelines, South Lake Union pipelines.** New conveyance structures, including piping and regulators, will convey CSO flows to the new CSO control facilities.
- **Elliott West outfall.** A new outfall into Elliott Bay at Myrtle Edwards Park will discharge treated flows from the Elliott West facilities to the bay. It will be 500 feet long and 60 feet deep.
- **Denny CSO outfall extension.** An extension of the existing outfall at the Denny Way regulator station will discharge untreated CSO flows not more than once per year, on average to the bay. This outfall will be 100 feet long and 20 feet deep.

The final environmental review document for the Denny Way/Lake Union project was issued in April 1998, and Ecology and the EPA approved the facilities plan later that year. Project completion is expected in 2004. King County's estimated cost for its Phase 3/4 project is $142.2 million.

Henderson/Martin Luther King Way/Norfolk CSO Control Project

As noted in the *1995 CSO Update*, all County overflows to Lake Washington were believed to have been controlled to one untreated discharge per year by 1988. However, system modeling and routine maintenance revealed that discharges were continuing from the Martin Luther King Way diversion structure and Henderson Street CSO.

The Henderson/Martin Luther King Way/Norfolk CSO Control Project is an approximately $72 million project involving rehabilitation of the existing Henderson pump station; increasing pumping capacity to 22 million gallons per day at the Henderson pump station; constructing new force mains; constructing a 14 to16 feet, 8 inch diameter, 3,600-ft long treatment/storage tunnel; and constructing a new overflow pipe to carry overflows from the tunnel to the existing Norfolk CSO outfall in the Duwamish River. Construction on the project will begin in 2001, and the project is expected to be operational by early 2004. The project will control overflows in the area to one untreated discharge per year at the Norfolk overflow and reduce the existing Henderson/Martin Luther King Way discharges to Lake Washington to one event per year on average or less.

CHAPTER 5

CHAPTER 5
KING COUNTY'S
REGIONAL WASTEWATER
SERVICES PLAN

This chapter briefly discusses the strategies included in the draft *Regional Wastewater Services Plan,* projects of the CSO Program included in the final *Regional Wastewater Services Plan,* and a brief overview of environmental documentation of CSO control projects and where specific CSO projects can be found in CSO planning documents.

The King County *RWSP* Planning Process

King County's comprehensive sewer plan, the *Metropolitan Seattle Sewerage and Drainage Survey,* is more than 40 years old. Although it has been amended many times over the years, the plan needed updating to reflect changed circumstances and future conditions.

Estimates show that parts of King County's existing wastewater treatment system will reach its capacity by 2010. Some conveyance pipelines will reach their capacity before 2010. When this happens, compliance with regulations, commitments to current customers, and the ability to provide wastewater services to new customers will be at risk. Sewer overflows, backups, permit violations, and possible building moratoria may result if additional capacity is not provided. Updating the comprehensive plan was the first step toward providing the needed additional capacity.

Public participation was the foundation of the whole *RWSP* planning process. The process began with an extensive interview process involving citizens, wastewater customers, community and environmental advocates, and local elected officials. The information and input from the public participation effort formed the basis for a set of planning objectives used to develop and evaluate over 60 preliminary wastewater system alternatives. Eventually, the 60 alternatives were reduced to four basic service strategies. The principal elements of each strategy were as follows:

> **Service Strategy 1--**Expand both the plants in Renton and Seattle to increase system capacity. Service Strategy 1 also included a list of CSO control projects and schedule of implementation to control all County overflows by 2043.
>
> **Service Strategy 2--**Build a new 35-million gallons per day (mgd) treatment plant in the northern part of the service area in 2018 and expand its capacity to 65 mgd by 2032. This strategy would have also expanded both existing treatment plants. This service strategy included the same list of CSO control projects and schedule of implementation as Service Strategy 1.

Service Strategy 3--Build a new 35-mgd north end plant by 2010, and expand the capacity of the new plant to 89 mgd by 2030. In addition, expand the plant in Renton, but not the plant in Seattle. Service Strategy 3 included the same list of CSO control projects and schedule of implementation as Service Strategies 1 and 2.

Service Strategy 4--Expand average wet weather capacity at both the plants in Renton and Seattle and construct an 18-mile long tunnel and force main by 2020 between Kenmore and the plant in Renton. Because of the CSO storage provided by the tunnel, the list of CSO control projects could be shortened considerably. However, in spite of reducing the number of CSO control projects, the cost of the tunnel made this service strategy the most expensive of the four.

These four strategies were included in an *RWSP* draft plan published in May 1997. The County held public meetings and workshops to obtain citizen input to the draft plan, and some modifications were made to the strategies as a result. The County also prepared a draft environmental impact statement (EIS) based on the *RWSP* draft plan. The draft EIS was published, comments were received, and a final EIS incorporating comments and responses was published in April 1998. Also in April 1998, the King County Executive offered his *Executive's Preferred Plan*, which was based on Service Strategy 3, highlighted by early construction of a new treatment plant in north King County or southern Snohomish County. The *Executive's Preferred Plan* accelerated the CSO control project schedule, achieving one-event-per-year control by 2030 rather than 2043 as called for in the draft *RWSP*.[1] The final plan adopted by the King County Council in November 1999 included the same CSO projects as included in the *Executive's Preferred Plan* as well as some additional policies. For example, Policy CSOCP-8 states that prior to the *2005 CSO Update*, the program shall undergo review. Program review includes, but is not limited to the following: maximizing use of existing CSO control facilities; identifying the public and environmental health benefits of continuing the CSO control program; ensuring projects are in compliance with new regulatory requirements and objectives such as the ESA and the Wastewater Habitat Conservation Plan. Appendix C includes the *Regional Wastewater Services Plan* policies associated with the CSO program.

Inflow and Infiltration Element of the *RWSP*

King County recently began implementation of a Regional Inflow/Infiltration (I/I) Control Program in the separated portions of its collection system. This control program is an element of the *RWSP* that the King County Council adopted in late 1999 and the program concept has undergone some refinements since that time. The initial phase of the Regional I/I Control Program involves a comprehensive assessment of I/I in the 32 locally owned separated sewer systems tributary to King County.

[1] The *Executive's Preferred Plan* was adopted by the King County Council in November 1999 with some revisions. The CSO portion of this plan did not change significantly from the control program outlined in the *Executive's Preferred Plan*.

As part of this work, King County will assess I/I levels within each component agency's collection system, identify egregious I/I sources, complete pilot projects to demonstrate the effectiveness of rehabilitation technologies, and develop a comprehensive long term control strategy for review and adoption by the King County Council in 2005. This initial phase will take five years to complete and involve the expenditure of $31 million in King County regional sewer funds.

The second phase of the Regional I/I Control Program will begin with adoption of the long-term I/I control strategy in 2005. This strategy involves the establishment of enforceable standards and acceptable I/I levels within each of the local sewer systems. This phase also includes defining King County's role in funding local agency rehabilitation projects. While primarily expected to benefit the County in decreasing conveyance and treatment capacity needs, some small amount of conveyance capacity may be created to capture CSO.

CSO Program Element of the *RWSP*

The CSO element of the *RWSP* replaced the separation projects listed in the *1988 CSO Plan* with over 20 new projects to be completed over a 30-year period. When those projects are complete, King County will have controlled all its CSOs to one untreated discharge per year on average as required by Department of Ecology regulations.

The CSO control element utilizes two basic approaches to reducing untreated discharges. The first approach involves constructing large, underground storage tanks. These storage facilities will fill during storm events as conveyance and treatment capacity is exceeded. The stored flows will be pumped to the West Treatment Plant in Seattle once the storm subsides and capacity becomes available once again. The second approach involves treating the combined sewage at existing CSO outfall locations by removing solids, probably providing control of floatable materials, and possibly disinfecting the effluent before it is discharged. Many *RWSP* CSO control projects include a combination of these two approaches.

In scheduling CSO control projects under the *RWSP*, King County's first priority was controlling discharges that impact bathing beaches. Discharges along Puget Sound beaches and the east end of the Lake Washington Ship Canal are thus scheduled first due to extensive use of these areas for recreation and their ready access from the shoreline. The Duwamish River discharges are scheduled to follow. Facilities to control CSOs at the western end of the Ship Canal will be the last to be built, since substantial control has already been achieved in this area.

It is possible that King County may refine the proposed projects or their schedule before they are built in order to take advantage of some new technology, to increase project cost-effectiveness, or because of changing conditions. The order of projects might need to be changed, with individual projects accelerated to accommodate fish recovery, Total Maximum Daily Load planning initiatives, or sediment remediation efforts. Because the primary objectives of all the CSO projects--protecting human health, fish and wildlife, and improving receiving water quality--are consistent with the goals of those efforts, significant changes in the overall schedule do not appear likely. Figure 5-1 shows the priority of projects making up the CSO element of the *RWSP*.

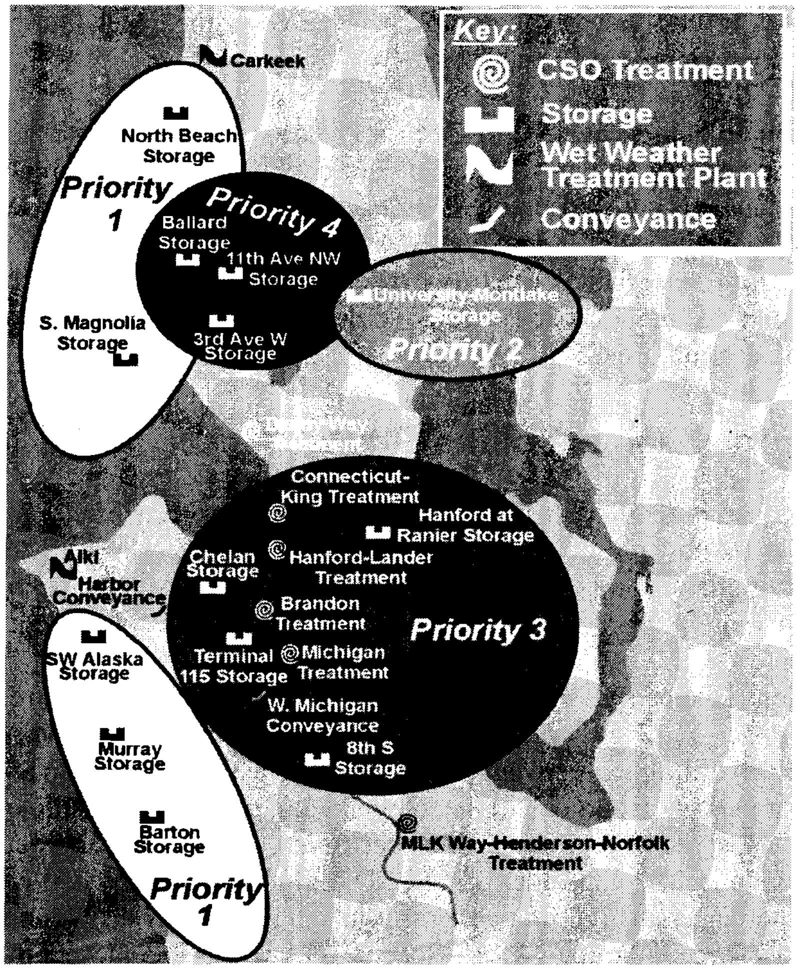

Figure 5-1: Priority of CSO Control Projects

Long-Term CSO Control Schedule and Costs

WAC 173-245-040 requires any sewerage agency with combined systems to prepare a long-term CSO reduction plan that includes a schedule for achieving the greatest reasonable reduction of CSOs (i.e., one untreated discharge on average per year) at the earliest possible date. The *RWSP* is the Comprehensive Sewer Plan amendment and this report updates it. Achieving CSO reduction is expensive; King County has spent over $60 million on past projects, will be spending around $195 million on current projects, and approximately $311 million more on future projects (1998 dollars).

Table 4-1 lists all of the CSO projects that constitute the CSO element of the *RWSP*. The table includes a brief description of the facilities to be constructed, a capital cost estimate

Appendix E: Glossary

for each project (in 1998 dollars), and a proposed project completion date. Further detail can be found in the *RWSP* documents.

Table 5-1: CSO Projects in the RWSP

CSO Project	Project Description	1998 Capital Cost, $mil	Year Controlled
Completed *1988 Plan* Projects		$60.5	1997
Committed Projects[a]		$194.9	2004
S. Magnolia	1.3 MG storage tank	$6.8	2010
SW Alaska St.	0.7 MG storage tank	$4.3	2010
Murray	0.8 MG storage	$5.1	2010
Barton	Pump station upgrade	$9.3	2011
North Beach	Storage tank and pump station expansion	$3.9	2011
University & Montlake	7.5 MG storage	$53.5	2015
Hanford #2	3.3 MG storage/treatment tank	$27.9	2017
West Point Improvements	Primary/secondary enhancements	$16.9	2018
Lander	1.5 MG storage/treatment at Hanford	$26.0	2019
Michigan	2.2 MG storage/treatment tank	$32.4	2022
Brandon	0.8 MG storage/treatment tank	$13.1	2022
Chelan	4 MG storage tank	$18.3	2024
Connecticut	2.1 MG storage/treatment tank	$31.9	2026
King St.	Conveyance to Connecticut treatment	$3.2	2026
Hanford at Rainier	0.6 MG storage tank	$3.3	2026
8th Ave S	1.0 MG storage tank	$6.9	2027
West Michigan	Conveyance expansion	$0.4	2027
Terminal 115	0.5 MG storage tank	$3.9	2027
3rd W	5.0 MG storage tank	$28.3	2029
Ballard	1.0 MG storage tank (40% King County)	$2.9	2029
11th Ave. West	2.0 MG storage tank	$12.9	2030
Totals		**$566.6**	

[a] Includes Harbor, Denny, Dexter, Norfolk and Henderson/MLK Way.

Environmental Documentation

Future CSO projects have been identified in the *RWSP* and the *Regional Wastewater Services Plan Draft* and *Final Environmental Impact Statements.* These documents were written at the programmatic level of environmental review. Project-level environmental review will occur prior to the construction of CSO facilities.

Impacts of the Harbor CSO pipeline are covered in the SEPA documents associated with the Alki Transfer/CSO Facilities Project as the pipe was laid in a trench that was already being excavated for other elements of the Alki Project. The *Final National Environmental Policy Act Environmental Assessment Addendum No. 2*, January 1995 includes information on the Harbor CSO element of the project.

Impacts of the Denny Way/Lake Union CSO Control Project are included in the *Final SEPA Supplemental EIS and NEPA Environmental Assessment* dated July 1998. In 1999, with the listing of Chinook salmon as a threatened species, the Denny Way/Lake Union Project was required to be reviewed by the National Marine Fisheries Service for its potential of harming or placing in jeopardy Chinook salmon. The National Marine Fisheries Service found that there was a potential for harm, but not jeopardy. The project will include additional mitigation to reduce the level of potential harm that could result in the construction of the project. It is anticipated that such review, both formal (where there is a federal link) and informal (where there is not) will become common for County CSO projects.

A Determination of Non-Signficance under WAC 197-11-340(2) was issued for the Henderson/MLK Way/Norfolk project as King County determined that the project did not have a probably significant adverse impact on the environment. Thus, an Environmental Impact Statement was not required for the project.

Table 5-2 includes information on where CSO projects can be found within specific planning documents.

Table 5-2: CSO Projects Within Specific Planning Documents

	NOV. 1985 FEIS	JULY 1986 FSEIS	1988 PLAN	1988 PLAN	1995 CSO UPDATE	RWSP& FEIS 1998/99	2000 CSO Update
CATAD IMPROVEMENTS							
CATAD Improvements North	X		X		X		X
CATAD Improvements South	X		X		X		X
TREATMENT							
Denny Way CSO Treatment	X						X
Stormweather Treatment at Alki	X		X				
Stormweather Treatment at Carkeek	X		X				
Duwamish CSO Treatment	X			X			
Kingdome CSO Treatment	X						
Norfolk/Henderson/MLK Way CSO							X
Hanford #2 Storage/Treatment Tank						X	X
Lander Storage/Treatment Tank						X	X
Brandon Storage/Treatment Tank						X	X
Connecticut Storage/Treatment Tank						X	X
STORAGE							
Fort Lawton Tunnel	X		X				
University Regulator Storage	X		X	X			
Washington Park Storage	X						
Dexter Regulator Storage	X			X			
Harrison Street Tunnel	X						
Denny Way Storage	X				X		
Harbor Regulator Storage	X				X		
Henderson Street Storage	X						
Storage in Abandoned EBI		X					
Third Avenue West Storage				X			
Ballard Regulator Storage				X			
Ballard No. 1 Weir Storage				X			
South Magnolia Storage						X	X
SW Alaska Storage						X	X
Murray CSO Storage Tank						X	X
North Beach Storage Tank & Pump						X	X
University/Montlake Storage Tank						X	X
Chelan Storage Tank						X	X
Hanford at Rainier Storage Tank						X	X
Terminal 115 Storage Tank						X	X
Ballard Storage Tank						X	X
3rd Ave W Storage Tank						X	X
11th Ave W Storage Tank						X	X
SEPARATION							
Hanford Tunnel Separation	X		X				
University Regulator Separation	X		X				
Michigan Street Separation/Storage	X		X				
Diagonal Separation	X		X				
Kingdome/Industrial Area Separation	X		X				
NSA Separation		X		X			
Duwamish Separation		X					
Hanford Sep/Bayview Storage			X				

Table 5-2: CSO Projects Within Specific Planning Documents							
	NOV. 1985 FEIS	JULY 1986 FSEIS	1988 PLAN	1988 PLAN	1995 CSO UPDATE	RWSP& FEIS 1998/99	2000 CSO Update
Lander Separation			X				
Denny Way Tunnel Partial			X		X		
Denny Local Partial Separation			X		X		
Ballard Basins 1-4 Separation				X			
University Basins 5-11 Separation				X			
Duwamish Basins 1-9 Separation				X			
OTHER PROJECTS							
Belvoir/30th NE Pumping	X						
Increase New Regional Interceptor		X					
Central Interceptor Expansion				X			
SW Lake Washington Interceptor				X			
W. Marginal Way Sewers				X			
Henderson/MLK Way/Norfolk					X		X
West Pt. Primary/Secondary						X	X
King St. CSO Conveyance						X	X
West Michigan Conveyance						X	X
Harbor CSO Pipeline					X		X

CHAPTER 6

CHAPTER 6 NEW REGULATIONS, POLICIES, INITIATIVES, AND TECHNOLOGIES AFFECTING THE CSO PROGRAM

A number of studies, initiatives, and policies could affect future CSO projects. King County plans and initiatives have included the *CSO Water Quality Assessment*, the *Sediment Management Plan*, and sediment recontamination studies of Elliott Bay. State programs, including the Water Quality Management Program and total maximum daily load (TMDL) assessments, also have potential implications to CSO projects. The recent listing of Puget Sound Chinook salmon and bull trout under the federal Endangered Species Act and the proposed listing of the Duwamish River as a Superfund site are examples of federal actions relevant for the CSO program. This chapter contains a summary of these plans and policies and their potential implications to the CSO program. The chapter also takes a look at several new control technologies that show promise to aid King County with its CSO control effort.

King County's *CSO Water Quality Assessment*

King County's 1999 *Combined Sewer Overflow Water Quality Assessment for the Duwamish River and Elliott Bay* (*CSO WQA*) reviewed the health of the Duwamish River and Elliott Bay estuary and the effects of CSO discharges. A computer model was developed as part of the *CSO WQA* to predict water and sediment quality conditions currently and in future scenarios. A risk assessment was undertaken to assess how aquatic life, wildlife, and humans could be at risk from chemicals and other changes in the water. The *CSO WQA* found that while there are possible risks to fish, wildlife, and humans associated with the estuary as it exists today, the majority of these risks are not expected to decline significantly if CSO discharges are removed from the estuary. Specifically, the *CSO WQA* found:

- ***Risks to aquatic organisms in the water column.*** For fish and other aquatic organisms, there is no significant risk from chemicals in the water column, with or without continued CSO discharges. No significant risks to aquatic life from total suspended solids were identified. No risks to salmon were identified from direct exposure to chemicals in the water column or from dietary exposure. There appear to be no risks of increased salmon mortality or reduced salmon growth from consumption of amphipods in the estuary.

- ***Risk to sediment-dwelling organisms.*** For benthic organisms, the *CSO WQA* found potential risks from several chemicals, notably polychlorinated biphenyls (PCBs) and tributyltin. These chemicals generally come from sources other than CSOs. No to slight decreases in risks to benthic organisms from bis(2-ethylhexyl)phthalate, mercury, and polycyclic aromatic hydrocarbons (PAHs) with CSO removal. Baseline risks to benthic organisms from 1,4-dichlorobenzene are low but would decline further with control of CSOs.

- ***Risks to wildlife.*** Four wildlife species were evaluated in the *CSO WQA*: spotted sandpipers, river otters, bald eagles, and great blue herons. Each species is exposed to chemicals in the Duwamish River and Elliott Bay. Spotted sandpipers have a moderate to high risk from dietary exposure to lead in particular and also copper, PCBs, and zinc. CSOs contribute low amounts of lead, copper, and zinc and are not a significant source of PCBs. Low risks from lead also exist for river otters, bald eagles, and great blue herons. The risks to wildlife are not expected to change if CSOs were removed from the system because other sources contribute the majority of risk-related chemicals.

- ***Risks to humans.*** For humans, there are potential risks from eating seafood harvested in the study area. Health risks from arsenic and PCBs are significant for people who catch and eat seafood about twice per month. Removing CSOs would not reduce these risks because arsenic and PCBs are primarily entering the estuary through sources other than CSOs. There are potential risks from net fishing, swimming, windsurfing, and SCUBA diving. However, there are no predicted reductions in risks in removing CSOs because most PCBs and arsenic come from sources other than CSOs. There are potential risks from fecal coliforms and Giardia and viruses. With removal of CSOs, there are no predicted reductions in risks from fecal coliform concentrations because fecals also come from sources other than CSOs. With removal of CSOs, risks of infection from Giardia and viruses will be reduced, but the level of risk from other sources remains unknown. Since the highest level of risks from pathogens related to CSOs occur when they are discharging and immediately after, the Seattle-King County Health Department recommends that people avoid recreating near CSO locations for 48 hours after heavy rainfall to reduce the risk of illness due to CSO overflows.

The findings of the *CSO WQA* helped determine the priority of the CSO projects in the *RWSP*. The *CSO WQA* will continue to play an important role in long-term CSO control planning. The initial finding that CSOs have limited impact on salmon will be considered in developing salmon recovery plans and will allow King County to focus those plans on sources that pose greater risks.

King County's *Sediment Management Plan*

In May 1996, Ecology released its list of 49 contaminated sediment sites in Puget Sound. Nineteen of those contaminated sites are located in Elliott Bay. Seven of the Elliott Bay sites are near King County CSO outfalls (Denny Way, King Street, Lander Street, Hanford #2 , Chelan Avenue, Duwamish/Diagonal, and Brandon Street). King County developed its draft *Sediment Management Plan* to initiate a long-range sediment management strategy, particularly with respect to the seven contaminated sites listed by Ecology.

The draft *Sediment Management Plan* work examined remediation alternatives that could be used at the contaminated sites. Possible remediation technologies included source control/natural recovery, capping, and dredging with confined aquatic and upland disposal. A preliminary cost estimate was developed for each option and site. Cooperative projects with the City of Seattle, the Port of Seattle, and others were explored to help identify potential cost savings. Based on the options developed and the cost estimates, the draft *Sediment Management Plan* identified cost-effective strategies for cleaning up the seven sites.

Sediment Recontamination Studies

Sediment recontamination following remediation projects is also a concern to King County. Contaminants remaining in CSOs, treated wastewater, and stormwater discharges can settle offshore in remediated areas, recontaminating these areas.

Under Washington's sediment management standards, recontamination of sediments is not allowed except within approved sediment impact zones. In response to the NOAA consent decree and the state sediment management standards, King County and other groups have conducted a number of studies and activities to evaluate the potential for sediment recontamination in Elliott Bay. These studies include:

- ***Elliott Bay Capping Studies.*** In order to isolate contaminated sediments from marine habitats, King County (then Metro) and the City of Seattle each completed sediment capping projects in Elliott Bay. In 1990, Metro sponsored the Denny Way capping project. As noted in the environmental impact statement for the Denny Way/Lake Union CSO Control Project, part of the surface of the sediment cap is gradually becoming recontaminated by continuing discharges from the uncontrolled Denny Way CSO. King County may remediate the sediment cap after completion of the Denny Way project in 2004.

  The City of Seattle's Pier 53-55 capping project, conducted in 1992, covers 4.5 acres along the Seattle waterfront. Two years of site sampling revealed an unanticipated increase in PAH concentrations that were attributed to activities involved in removing pilings at an adjacent pier.

- ***Elliott Bay Waterfront Recontamination Study.*** Ecology, funded by the Elliott Bay/Duwamish Restoration Panel, conducted a field investigation along the central Seattle waterfront to identify potential sources of sediment recontamination, mechanisms of contaminant transport and resuspension, and sedimentation rates. The data generated from the 1993-1994 field investigation were combined with other available information to develop a conceptual model for the study area. This model can be used to help design remediation projects.

- ***Norfolk Recontamination Study.*** The assessments performed for the Norfolk CSO remediation project indicated that, while the CSO would be controlled adequately to prevent recontamination of remediated sediments, recontamination by phthalates may result from continuing stormwater discharges at the site. Further study is underway.

It is clear that sediments and sediment contamination are going to receive increased scrutiny. Sediment management may emerge as a significant element of the King County CSO control program in the future.

Total Maximum Daily Loads Program

When data shows that water quality standards are being violated from the introduction of human induced pollutants, the water body must be listed on the Washington State Department of Ecology's 303(d) list and a total maximum daily load (TMDL) must be performed. TMDLs refer to regulatory programs and associated technical studies intended to achieve several objectives:

- Identify the maximum load of a pollutant that a water body can tolerate without violating water quality standards
- Identify any excess of that pollutant
- Identify sources of the pollutant
- Allocate that maximum load among the sources
- Adopt a plan identifying actions that would end the excess loading of the pollutant.

The outcome of any TMDL planning effort on waterbodies receiving CSO overflows may include some type of limit or allocation for those CSOs, which could be total volume allocation (perhaps including limits even more stringent than one untreated overflow per year) and could also include other types of limitations, such as pounds of suspended solids (or some other constituent of concern) annually. TMDLs may also make sediment remediation a higher priority and force changes in the King County CSO control project schedule.

To ensure that TMDL planning accurately reflects the causes of pollution and develops balanced correction plans, King County offered to work with Ecology on certain TMDL studies. The joint King County/Ecology TMDL project has begun to address the following concerns:

- Contaminated sediments in the Duwamish River and Elliott Bay.
- Contaminated sediments in the Ship Canal and Lake Union.

- Impaired water quality (associated with fecal coliform bacteria, pH, dissolved oxygen, temperature, mercury) in the Green/Duwamish River.

King County's sediment TMDL planning effort is focused first on developing the initial TMDL process for sediments within Elliott Bay, the Duwamish River, the Ship Canal, and Lake Union. Technical work to support TMDL's in the Green/Duwamish River must involve the other jurisdictions effected by the TMDLs and this will follow its own track dictated by those partnerships. Supporting the development of new pathogen standards will be the third priority of King County's TMDL's efforts. Development of a sediment TMDL for the Duwamish River and Elliott Bay will involve many agencies and organizations, including the City of Seattle, the Port of Seattle, King County, Ecology, EPA, the Corps of Engineers, the Washington Department of Natural Resources, the Washington Department of Transportation, tribal governments, the City of Tukwila, the Boeing company, and several shipyards. The development of a collaborative stakeholder process is another focus of the joint Ecology/County project.

Ecology's Water Quality Management Program

Ecology has established a watershed-based program to assess water quality conditions, issue wastewater discharge permits, and take other protective measures. The state has been divided into 23 water quality management areas. Every year, four or five management areas are scheduled for a five-year study. During the data collection/analysis phase of each study, water quality total maximum daily load values may be established.

The Cedar River/Green River management area has gone through the initial scoping process and begun the data collection phase. Ecology has given a small grant to King County which will contribute to the county's extension of to *CSO WQA* risk assessment model to the Green River's upper sections. The ultimate outcome of Ecology's data collection and analysis effort will be a TMDL implementation plan for the entire Green/Duwamish River, which could potentially affect CSO planning. TMDL studies potentially affecting the CSO program are also scheduled for Lake Union and the Ship Canal.

Endangered Species Act

Recently, the National Marine Fisheries Service listed the Puget Sound Chinook salmon and bull trout as threatened species under the federal Endangered Species Act (ESA). The intent of the listing was to protect the fish and their habitat. The protection of water quality and habitat is also a primary objective of King County's CSO control program.

King County responses to the Chinook salmon listing include the following:

- ***Tri-County ESA Planning.*** Prior to the listing of Puget Sound Chinook salmon and bull trout, King, Pierce, and Snohomish Counties began working together to restore and maintain fish populations and protect the water bodies on which they rely. The Tri-County ESA response work plan includes regional coordination and public involvement tasks, an inventory of activities potentially affecting fish, and a basic action package for protection.

- ***King County's ESA Planning.*** King County has completed its own inventory of activities, programs, and regulations that could potentially affect listed species and has identified planned early actions. This inventory has been submitted to the National Marine Fisheries Service (NMFS) and the U.S. Fish and Wildlife Service. (USFWS). Upcoming changes to King County's wastewater services as proposed in the *RWSP* have led King County to begin development of a habitat conservation plan under Section 10 for wastewater, with a first phase to be completed by mid-2003. The plan will address the impact of wastewater facilities on threatened species and their critical habitat and will incorporate actions to minimize or eliminate that impact and to contribute to species recovery. King County has requested that NMFS and WSFWS include King County's wastewater system under the 4(d) rule. A determination is expected on this request in Spring 2000.

National Marine Fisheries Service and the U.S. Fish and Wildlife Service will review the tri-county and King County's ESA response plans to determine whether additional limitations or regulations are required. There is considerable uncertainty about how these response plans will be received. It is likely that there will be negotiation between the fisheries services and local jurisdictions regarding the appropriate level of fish protection.

The Chinook salmon listing may force modifications to CSO individual projects or the program schedule. The long-range prioritization of projects and the project schedule may require modification if fish are found to be at risk from CSO discharges at particular sites and new CSO control projects may require additional environmental mitigation to protect fish and their habitat.

Potential Duwamish River Superfund Listing

In April 1999, EPA released data gathered from its 1998 site assessment of the Duwamish River. Preliminary evaluation indicates that the area is eligible for inclusion on the national priorities list of Superfund hazardous materials sites under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA). Should such a listing occur, it would identify the area as one that appears to "warrant remedial actions." Inclusion on the list results in the imposition of a number of requirements for remediation, including a detailed strategy for investigation of the problem and a proposed approach for cleanup, pollutant source controls, and community involvement.

Through the work on the Green/Duwamish River sediment TMDL project, King County, the Port of Seattle, and the City of Seattle had begun the process of evaluating the potential for a coordinated approach to sediment contamination issues in the Duwamish estuary, Elliott Bay, and Lake Union. With the proposed listing of the Duwamish as a Superfund site, this group was redefined to include Boeing. In an attempt to accomplish sediment clean-up faster and more cost-effectively than can be done under Superfund, this group is working together to negotiate an alternative to Superfund with EPA and Ecology.

Promising CSO Control Technologies

One of the preferences revealed through public participation in the *RWSP* planning process was the desire to maintain flexibility to accommodate changes in regulations, population, public opinion, and technology. Technology changes over time, and it is important that King County not be too firmly committed to today's technology for facilities that may be constructed 30 years from now. In response to the public desire to keep up with developing technologies, the *2000 CSO Control Update* team surveyed new and emerging CSO control technologies.

The Task 300 report summarizes that research effort. At a workshop, the project team identified a number of technologies that appeared to warrant further study. These promising new technologies are described in the following pages. Between now and the *2005 CSO Update*, the County may do further research into these technologies. As the individual CSO control projects which comprise the CSO control plan reach the predesign stage, promising new technologies will be evaluated and substituted, where appropriate.

Ballasted Sedimentation

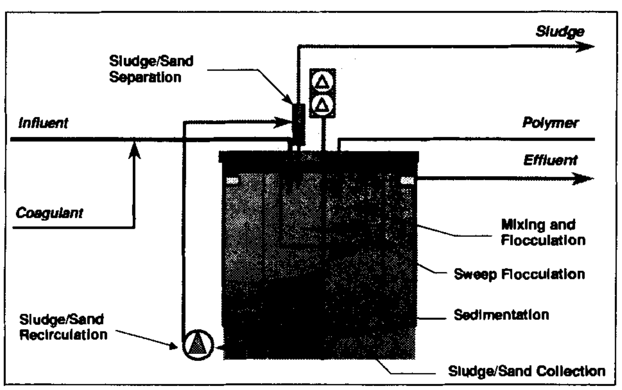

Figure 6-1: Ballasted sedimentation--U.S. Filter Microsep Process

Ballasted sedimentation is a process in which CSO is mixed with a chemical coagulant, polymer, and micro-sand. The coagulant gathers the finely divided CSO suspended solids into flocculated masses, or flocs. The polymer attaches smaller flocs to the micro-sands. The micro-sands weight the flocs, causing them to settle rapidly. Ballasted sedimentation could provide solids removal equal to or better than a traditional sedimentation tank but in a footprint one tenth the size, thereby reducing construction costs.

Continuous Deflective Separation

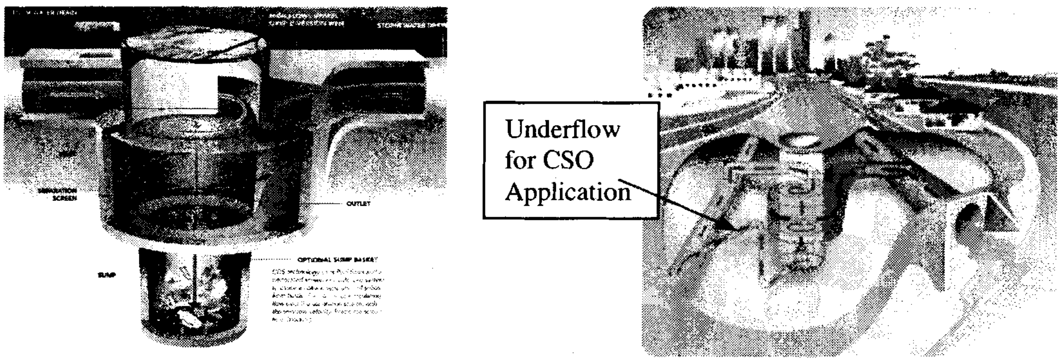

Figure 6-2: Continuous Deflective Separation

Developed in Australia, continuous deflective separation (CDS) is an innovative technology for removing solids and floatables. Influent enters the CDS unit on the perimeter of a circular, perforated screen. The screen traps floatables and settleable materials while the filtered water passes through to the outfall or downstream treatment process. Continuous deflective separation technology offers the advantages of complete removal of floatable materials and substantial removal of suspended solids without mechanical operations. The technology may not meet Ecology requirements for CSO treatment, however. Downstream processes for further solids removals are likely to be required. CDS technology could provide cost-effective pretreatment ahead of other solids removal technologies, such as compressed media filtration.

Compressed Media Filtration

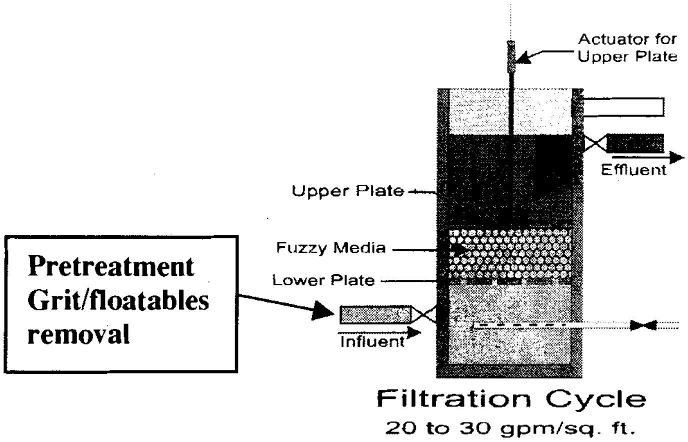

Figure 6-3: Compressed Media Filtration--Fuzzy Filter

A compressed media filter (e.g., the Fuzzy Filter™) has a filter medium composed of highly porous fiber spheres contained between two horizontal, perforated plates. Adjusting the distance between the plates varies the degree of compression and the porosity of the filter medium. The level of compression can be varied to suit the properties of the influent.

Filtration has been shown to be a reliable way of reducing suspended solids in wastewater. A 50 percent reduction can be reliably achieved. Pretreatment to remove grit, debris, and floatables is required, however. This process could be added to the *RWSP* on-site treatment projects if it were found that the solids removal efficiency of those processes was insufficient. Alternatively, a combination of CDS and compressed media filters could replace the *RWSP* projects if the economics of providing filtration for the maximum *RWSP* design flows are favorable.

Ultraviolet Disinfection

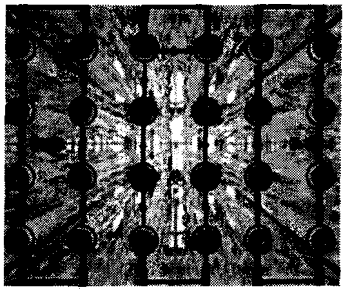

Figure 6-4: UV Lamp Bank

For disinfection of CSO, treated CSO is passed through a chamber filled with lamps that emit UV light. The UV rays kill organisms by inducing photochemical changes in the cell's DNA, thus stopping their ability to replicate. The ultraviolet light is emitted from lamps typically submerged in an open or closed channel. The lamp chamber must provide a wastewater detention time of 6 to 10 seconds. The size and number of lamp units required depends on the expected flow rates.

Suspended solids concentration and particle size can affect ultraviolet effectiveness. High rate solids removal via upstream treatment is necessary, as the suspended solids concentration entering the lamp chamber must not exceed 50 milligrams per liter. Ultraviolet disinfection was considered for the Denny Way/Lake Union CSO Control Project, but since suspended solids concentrations in effluent from the Denny Way facilities are expected to be relatively high, this technology was not selected. Applicability of ultraviolet disinfection for other projects will depend on the degree of treatment provided. The current *RWSP* projects call for primary treatment, which is not expected to result in effluent suspended solids concentrations low enough for reliable disinfection with ultraviolet light. If higher levels of treatment were provided, (e.g., ballasted sedimentation or CDS combined with compressed media filters), then ultraviolet disinfection could become a viable alternative.

Down Spout Disconnection Programs

Inflow and Infiltration also affect King County's CSO problem. During or following storms, infiltration from groundwater can enter the wastewater system from leaky sewer pipes. Inflow can enter the system from down spout connections from roofs, storm drains, and manhole covers. In a combined system, inflow is the greater source of high flows and overflows, but because there are no storm sewers, much of the inflow is inevitable. Certain kinds of inflow can be eliminated, such as inflow from down spouts in areas where soils can absorb the runoff or where a stormwater system exists. Some municipalities have adopted ordinances requiring that down spouts be disconnected from the sewer system, and some municipalities have given subsidies to homeowners who disconnect their roof drains. These efforts have met with varying degrees of success.

King County has looked at possible down spout disconnection programs and has considered a pilot project to test the flow reduction that might be achieved with such a program and assess the cost-effectiveness. It is also possible that CSO projects in certain areas (e.g., Magnolia and West Seattle) might include roof drain disconnection, side sewer repair, or some other infiltration and inflow reduction element.

APPENDICES

Appendices

Appendix A: WAC 173-245

DOMESTIC AND INDUSTRIAL WASTEWATER FACILITIES

WAC 173-240-160 Requirement for professional engineer. (1) All required engineering reports, and plans and specifications for the construction or modification of wastewater facilities shall be prepared under the supervision of a professional engineer licensed in accordance with chapter 18.43 RCW. All copies of these documents submitted to the department for review shall bear the seal of the professional engineer under whose supervision they have been prepared.

(2) Upon request of the owner, the department may waive the above requirement for construction or modification at industrial wastewater facilities.

[Statutory Authority: Chapters 43.21A and 90.48 RCW. 83-23-063 (Order DE 83-30), § 173-240-160, filed 11/16/83. Statutory Authority: RCW 90.48.110. 79-02-033 (Order DE 78-10), § 173-240-160, filed 1/23/79. Formerly chapter 372-20 WAC.]

WAC 173-240-170 Right of inspection. Pursuant to RCW 90.48.090, the department or its authorized representative shall have the right to enter at all reasonable times in or upon any property, public or private, for the purposes of inspection or investigation relating to the pollution or possible pollution of the waters of the state, including the inspection of construction activities related to domestic or industrial wastewater facilities.

[Statutory Authority: Chapters 43.21A and 90.48 RCW. 83-23-063 (Order DE 83-30), § 173-240-170, filed 11/16/83. Statutory Authority: RCW 90.48.110. 79-02-033 (Order DE 78-10), § 173-240-170, filed 1/23/79. Formerly chapter 372-20 WAC.]

WAC 173-240-180 Approval of construction changes. All wastewater facilities subject to the provisions of this regulation shall be constructed in accordance with the plans and specifications approved by the department. Any contemplated changes during construction, which are significant deviations from the approved plans, shall first be submitted to the department for approval.

[Statutory Authority: Chapters 43.21A and 90.48 RCW. 83-23-063 (Order DE 83-30), § 173-240-180, filed 11/16/83. Statutory Authority: RCW 90.48.110. 79-02-033 (Order DE 78-10), § 173-240-180, filed 1/23/79. Formerly chapter 372-20 WAC.]

Chapter 173-245 WAC

SUBMISSION OF PLANS AND REPORTS FOR CONSTRUCTION AND OPERATION OF COMBINED SEWER OVERFLOW REDUCTION FACILITIES

WAC

WAC 173-245-010 Purpose and scope. This chapter establishes a procedure and criteria for implementing RCW 90.48.480 which requires "the greatest reasonable reduction of combined sewer overflows at the earliest possible date." It applies to municipalities whose sewer system includes combined sewer overflow (CSO) sites.

[Statutory Authority: RCW 90.48.035. 87-04-020 (Order DE 86-34), § 173-245-010, filed 1/27/87.]

WAC 173-245-015 General requirements. (1) All CSO sites shall achieve and at least maintain the greatest reasonable reduction, and neither cause violations of applicable water quality standards, nor restrictions to the characteristic uses of the receiving water, nor accumulation of deposits which: (a) Exceed sediment criteria or standards; or (b) have an adverse biological effect.

(2) This chapter shall not negate specific CSO reduction projects, programs, and schedules which the department and a municipality have agreed upon prior to this chapter's effective date. However, the provisions of this chapter shall still apply.

[Statutory Authority: RCW 90.48.035. 87-04-020 (Order DE 86-34), § 173-245-015, filed 1/27/87.]

WAC 173-245-020 Definitions. As used in this chapter:

(1) "At-site treatment" means treatment and discharge of combined sewage at the CSO site.

(2) "Baseline annual CSO volume and frequency" means the annual CSO volume and frequency which is estimated to occur based upon the existing sewer system and the historical rainfall record.

(3) "Best management practices" means use of those practices which will best reduce the amount of pollution caused by nonpoint sources so that pollutant loadings in combined and storm sewer flows during rainfall events are minimized.

(4) "Combined sewage" means the mixture of sanitary sewage, infiltration, and inflow.

(5) "Combined sewer" means a sewer which has been designed to serve as a sanitary sewer and a storm sewer, and into which inflow is allowed by local ordinance.

(6) "Combined sewer overflow (CSO)" means (a) the event during which excess combined sewage flow caused by inflow is discharged from a combined sewer, rather than conveyed to the sewage treatment plant because either the capacity of the treatment plant or the combined sewer is exceeded.

(7) "CSO reduction plan" means a comprehensive plan for attaining the greatest reasonable reduction of CSO's at the earliest possible date. The requirements for a CSO reduction plan are as further described in this chapter.

(8) "Department" means the department of ecology.

(9) "Disinfection" means the selective destruction of disease-causing and bacterial indicator group organisms.

(10) "Domestic wastewater facilities" means any CSO treatment/control facility included under the definition of

domestic wastewater facilities as defined in chapter 173-240 WAC.

(11) "In-line storage" means storage of sewage within the sewer pipes through the use of regulators and gates.

(12) "Infiltration" means the addition of ground water into a sewer through joints, the sewer material, cracks, and other defects.

(13) "Inflow" means the addition of rainfall-caused surface water drainage from roof drains, yard drains, basement drains, street catch basins, etc., into a sewer.

(14) "NPDES" means the National Pollutant Discharge Elimination System.

(15) "Off-line storage" means storage of sewage adjacent to the sewer pipe in a tank or other storage device.

(16) "Primary treatment" means any process which removes at least fifty percent of the total suspended solids from the waste stream, and discharges less than 0.3 ml/l/hr. of setteable solids.

(17) "Sanitary sewer" means a sewer which is designed to convey sanitary sewage and infiltration.

(18) "Sanitary sewage" means the mixture of domestic, commercial, and industrial wastewaters.

(19) "Secondary treatment" means any process which achieves the requirements of 40 CFR Part 133 as supplemented by state regulation and guidance.

(20) "Storm sewer" means a sewer which is designed to convey surface water drainage caused by rainfall.

(21) "Storm sewer/sanitary sewer separation" means construction of new storm sewers or new sanitary sewers so that sanitary sewage and surface drainage are conveyed in different sewers.

(22) "The greatest reasonable reduction" means control of each CSO such that an average of one untreated discharge may occur per year.

[Statutory Authority: RCW 90.48.035. 87-04-020 (Order DE 86-34), § 173-245-020, filed 1/27/87.]

WAC 173-245-030 Submission of plans. Municipalities shall:

(1) Obtain the approval of the department for CSO reduction plans by January 1, 1988. This deadline may be extended by the department, when that authority is granted.

(2) Submit plans to the department at least sixty days prior to the time approval is desired.

(3) Incorporate CSO reduction plans into their respective general sewer plans and into plans for new or upgraded sewage treatment facilities.

[Statutory Authority: RCW 90.48.035. 87-04-020 (Order DE 86-34), § 173-245-030, filed 1/27/87.]

WAC 173-245-040 CSO reduction plan. (1) The CSO reduction plan shall be sufficiently complete so that plans and specifications can be developed from it for projects which may proceed into design within two years of plan submittal. Sufficient detail of any remaining projects shall be provided such that detailed engineering reports can be prepared in the future.

(2) CSO reduction plans shall include the following information together with any other relevant data as requested by the department.

(a) Documentation of CSO activity. Municipalities shall complete a field assessment and mathematical modeling study to establish each CSO's location, baseline annual frequency, and baseline annual volume; to characterize each discharge; and to estimate historical impact by:

(i) Flow monitoring and sampling CSO's. Monitoring and sampling at one or more CSO sites in a group which are in close proximity to one another shall be sufficient if the municipality can establish a consistent hydraulic and pollutant correlation between/among the group of CSO sites. Sampling may not be required for CSO sites which serve residential basins; and

(ii) Developing a rainfall/stormwater runoff/CSO model to simulate each CSO site's activity; and

(iii) Verifying the model's accuracy with data collected under (a)(i) of this subsection; and

(iv) In circumstances where an historical impact may be discernible, observing and sampling the receiving water sediments adjacent to each CSO site or group of sites to establish the presence and extent of any bottom deposits; and

(v) If the sewer service area upstream of a CSO site includes sanitary sewer sources other than domestic sewage, samples of the sediment deposits shall receive heavy metal analysis and organic pollutant screening. Pending review of results of these analyses, the department may require additional pollutant analyses. If two or more CSO sites serve the same industrial/commercial sources, sediment sampling adjacent to one representative CSO site may suffice.

(b) Analysis of control/treatment alternatives. Treatment/control alternatives, to achieve the greatest reasonable reduction at each CSO site, which shall receive consideration include but are not limited to:

(i) Use of best management practices, sewer use ordinances, pretreatment programs, and sewer maintenance programs to reduce pollutants, reduce infiltration, and delay and reduce inflow; and

(ii) In-line and off-line storage with at least primary treatment and disinfection at the secondary sewage treatment facility which is served by the combined sewer; or

(iii) Increased sewer capacity to the secondary sewage treatment facility which shall provide at least primary treatment and disinfection; or

(iv) At-site treatment equal to at least primary treatment, and adequately offshore submerged discharge. At-site treatment may include a disinfection requirement at CSO sites which are near or impact water supply intakes, potentially harvestable shellfish areas, and primary contact recreation areas; or

(v) Storm sewer/sanitary sewer separation.

(c) Analysis of selected treatment/control projects. Municipalities shall do an assessment of the treatment/control project or combination of projects proposed for each CSO site. The assessment shall include:

(i) An estimation of the water quality and sediment impacts of any proposed treated discharge using existing background receiving water quality data, and estimated discharge quality and quantity. The department may require a similar analysis for proposed storm sewer outfalls for basins which drain industrial and/or commercial areas; and

(ii) An estimation of the selected projects' impacts on the quality of effluent from and operation of a municipality's secondary sewage treatment facility. During wet weather flow conditions, a municipality shall maximize the rate and volume of flows transported to its secondary sewage treatment facility for treatment. However, such flows shall not cause the treatment facility to exceed the pollutant concentration limits in its NPDES permit; and

(iii) The estimated construction and operation and maintenance costs of the selected projects; and

(iv) The general locations, descriptions, basic design data, sizing calculations, and schematic drawings of the selected projects and descriptions of operation to demonstrate technical feasibility; and

(v) An evaluation of the practicality and benefits of phased implementation; and

(vi) A statement regarding compliance with the State Environmental Policy Act (SEPA).

(d) Priority ranking. Each municipality shall propose a ranking of its selected treatment/control projects. The rankings shall be developed considering the following criteria:

(i) Highest priority shall be given to reduction of CSO's which discharge near water supply intakes, public primary contact recreation areas, and potentially harvestable shellfish areas;

(ii) A cost-effectiveness analysis of the proposed projects. This can include a determination of the monetary cost per annual mass pollutant reduction, per annual volume reduction, and/or per annual frequency reduction achieved by each project;

(iii) Documented, probable, and potential environmental impacts of the existing CSO discharges.

(e) Municipalities shall propose a schedule for achieving "the greatest reasonable reduction of combined sewer overflows at the earliest possible date." (RCW 90.48.480.) If the agreed upon schedule exceeds five years, municipalities shall propose an initial five-year program of progress towards achieving the greatest reasonable reduction. Factors which municipalities and the department shall use to determine compliance schedules shall include but not be limited to:

(i) Total cost of compliance;

(ii) Economic capability of the municipality;

(iii) Other recent and concurrent expenditures for improving water quality; and

(iv) The severity of existing and potential environmental and beneficial use impacts.

[Statutory Authority: RCW 90.48.035. 87-04-020 (Order DE 86-34), § 173-245-040, filed 1/27/87.]

WAC 173-245-050 Plans and specifications. (1) The plans and specifications for a domestic wastewater facility are the detailed construction documents by which the owner or his contractor bid and construct the facility. The content and format of the plans and specifications shall be as stated in the state of Washington, "criteria for sewage works design," and shall include a listing of the facility design criteria and a plan for interim operation of facilities during construction.

(2) Plans and specifications for sewer line extensions shall include, as a separate report, an analysis of the existing collection and treatment systems ability to transport and treat additional flow and loading.

(3) Two copies of the plans and specifications shall be submitted to the department for approval prior to start of construction, excepting as waived under WAC 173-240-030(5). (See also, WAC 173-240-070.)

[Statutory Authority: RCW 90.48.035. 87-04-020 (Order DE 86-34), § 173-245-050, filed 1/27/87.]

WAC 173-245-055 Construction quality assurance plan. (1) Prior to construction a detailed plan must be submitted to the department showing how adequate and competent construction inspection will be provided.

(2) The construction quality assurance plan shall include:

(a) Construction schedule with a summary of planned construction activities, their sequence, interrelationships, durations, and terminations.

(b) Description of the construction management organization, management procedures, lines of communication, and responsibility.

(c) Description of anticipated quality control testing including type of test, frequency, and who will perform the tests.

(d) Description of the change order process including who will initiate change orders, as well as who will review, negotiate, and approve change orders.

(e) Description of the technical records handling methodology including where plans and specifications, as-built drawings, field orders, and change orders will be kept.

(f) Description of construction inspection program including inspection responsibility, anticipated inspection frequency, deficiency resolution, and inspector qualifications. (See also, WAC 173-240-075.)

[Statutory Authority: RCW 90.48.035. 87-04-020 (Order DE 86-34), § 173-245-055, filed 1/27/87.]

WAC 173-245-060 Operation and maintenance manual. (1) The proposed method of operation and maintenance of the domestic wastewater facility shall be stated in the engineering report or plans and specifications and approved by the department. The statement shall be a discussion of who will own, operate, and maintain the facility and what the staffing and testing requirements are. The owner shall follow the approved method of operation after the facility is constructed, unless changes have been approved by the department.

(2) In those cases where the facility includes mechanical components, a detailed operation and maintenance manual shall be prepared prior to completion of construction. The purpose of the manual is to present technical guidance and regulatory requirements to the operator to enhance operation under both normal and emergency conditions. Two copies of the manual shall be submitted to the department for approval prior to completion of construction.

(3) In order to assure proper operation during construction and timely review and approval of the final operation and maintenance manual, a draft manual shall be submitted in the early stages of the construction of a facility. In addition, manufacturer's information on equipment must be available to the plant operator prior to unit start-up.

(4) The operation and maintenance manual shall include the following list of topics. For those projects funded by the environmental protection agency the manual shall also follow the requirements of the EPA publication, *Considerations for Preparation of Operation and Maintenance Manuals.*

(a) The assignment of managerial and operational responsibilities to include plant classification and classification of required operators.

(b) A description of plant type, flow pattern, operation, and efficiency expected.

(c) The principal design criteria.

(d) A process description of each plant unit, including function, relationship to other plant units, and schematic diagrams.

(e) A discussion of the detailed operation of each unit and description of various controls, recommended settings, fail-safe features, etc.

(f) A discussion of how the treatment facilities are to be operated during anticipated maintenance procedures, and under less than design loading conditions, if applicable, such as initial loading on a system designed for substantial growth.

(g) A section on laboratory procedures including sampling techniques, monitoring requirements, and sample analysis.

(h) Recordkeeping procedures and sample forms to be used.

(i) A maintenance schedule incorporating manufacturer's recommendations, preventative maintenance and housekeeping schedules, and special tools and equipment usage.

(j) A section on safety.

(k) A section stating the spare parts inventory, address of local suppliers, equipment warranties, and appropriate equipment catalogues.

(l) Emergency plans and procedures.

(5) In those cases where the facility does not include mechanical components, an operation and maintenance manual, which may be less detailed than that described in subsection (4) of this section, shall be submitted to the department for approval prior to completion of construction. The manual shall fully describe the treatment and disposal system and outline routine maintenance procedures needed for proper operation of the system. (See also, WAC 173-240-080.)

[Statutory Authority: RCW 90.48.035. 87-04-020 (Order DE 86-34), § 173-245-060, filed 1/27/87.]

WAC 173-245-070 Declaration of construction completion. (1) Within thirty days following acceptance by the owner of the construction or modification of a domestic wastewater facility, the professional engineer in responsible charge of inspection of the project shall submit to the department (a) one complete set of record drawings or as-builts (b) a declaration stating the facilities were constructed in accordance with the provisions of the construction quality assurance plan and without significant change from the department approved plans and specifications.

(2) The declaration will be furnished by the department and will be the same form as WAC 173-245-075, declaration of construction of water pollution control facilities. The submission of the declaration is not necessary for sewer line extensions where the local government entity has received approval of a general sewer plan and standard design criteria. (See also, WAC 173-240-090.)

[Statutory Authority: RCW 90.48.035. 87-04-020 (Order DE 86-34), § 173-245-070, filed 1/27/87.]

WAC 173-245-075 Form—Declaration of construction of water pollution control facilities.

DECLARATION OF CONSTRUCTION OF WATER POLLUTION CONTROL FACILITIES

Instructions:

A. Upon completion, and prior to the use of any project or portions thereof, a professional engineer shall complete and sign this form, declaring that the project was constructed in accordance with the provisions of the construction quality assurance plan and with the plans and specifications and major change orders approved by the department of ecology.

B. If a project is being completed in phased construction, a map shall be attached showing that portion of the project to which the declaration applies. A declaration of construction must be submitted for each phase of a project as it is completed. Additional declaration forms are available upon request from the department of ecology offices listed below.

NAME AND BRIEF DESCRIPTION OF PROJECT: . . . .

. . . .

. . . .

NAME OF OWNER . . . . DOE PROJECT NO. . . .

ADDRESS . . . . DATE PROJECT OR PHASE COMPLETED . . .

CITY . . . . STATE . . . ZIP . .

DOE PLAN AND SPECIFICATION APPROVAL DATE . . . . .

I hereby declare that I am the project engineer of the above identified project and that said project was reviewed and observed by me or my authorized agent in accordance with the provisions of the construction quality assurance plan. I further declare that said project was to the best of my knowledge and information constructed and completed in accordance with the plans and specification and major change orders approved by the department of ecology and as shown on the owner's "as-built" plans.

. . . . SEAL

Signature or Professional Engineer

OF

DATE . . . . ENGINEER

Please return completed form to the department of ecology office checked below.

☐ SW Regional Office
Department of Ecology
Mail stop LU-11
7272 Cleanwater Lane
Olympia, WA 98504

☐ Central Regional Office
Department of Ecology
3601 W. Washington
Yakima, WA 98903

☐ NW Regional Office
Department of Ecology
4350 150th Ave. NE
Redmond, WA 98052

☐ Eastern Regional Office
Department of Ecology
East 103 Indiana Ave.
Spokane, WA 99207

☐ Municipal Division
Department of Ecology
PV-11
Olympia, WA 98503

(See also, WAC 173-240-095.)

[Statutory Authority: RCW 90.48.035. 87-04-020 (Order DE 86-34), § 173-245-075, filed 1/27/87.]

WAC 173-245-080 Requirement for certified operator. Each owner of a domestic wastewater treatment facility is required by chapter 70.95B RCW to have an operator, certified by the state, in responsible charge of the day to day operation of the facility. This requirement does not apply to a septic tank utilizing subsurface disposal. The certification procedures are set forth in chapter 173-230 WAC. (See also, WAC 173-240-100.)

[Statutory Authority: RCW 90.48.035. 87-04-020 (Order DE 86-34), § 173-245-080, filed 1/27/87.]

WAC 173-245-084 Ownership and operation and maintenance. (1) Domestic sewage facilities will not be approved unless ownership and responsibility for operation and maintenance is by a public entity except as provided in subsections (2) and (3) of this section. If a waste discharge permit is required it must be issued to the public entity. Nothing herein precludes a public entity from contracting operation and maintenance of domestic sewage facilities.

(2) Ownership by nonpublic entities may be approved if the department determines such ownership is in the public interest; provided there is an enforceable contract, approved by the department, between the nonpublic entity and a public entity with an approved sewer general plan which will assure immediate assumption of the system under the following conditions:

(a) Treatment efficiency is unsatisfactory either as a result of plant capacity or physical operation; or

(b) If such assumption is necessary for the implementation of a general sewer plan.

(3) The following domestic wastewater facilities would not require public entity ownership, operation, and maintenance:

(a) Those facilities existing or approved for construction as of the effective date of this section, until such time as the facility is expanded to accommodate additional development.

(b) Those facilities that serve a single nonresidential, industrial, or commercial establishment. Commercial/industrial complexes serving multiple owners or tenants and multiple residential dwelling facilities such as mobile home parks, apartments, and condominiums are not considered commercial establishments for the purpose of this section. (See also, WAC 173-240-104.)

[Statutory Authority: RCW 90.48.035. 87-04-020 (Order DE 86-34), § 173-245-084, filed 1/27/87.]

WAC 173-245-090 Schedule updates—Monitoring—Reporting. (1) By the anniversary date of its sewage treatment plant NPDES permit, in conjunction with its annual assessment for prevention of facilities overloading where applicable, a municipality shall submit an annual CSO report to the department for review and approval which:

(a) Details the past year's frequency and volume of combined sewage discharged from each CSO site, or group of CSO sites in close proximity. Field monitoring shall be necessary to estimate these parameters. The report shall indicate whether a CSO site or group of sites has increased over the baseline annual condition. If any increase has occurred, the municipality shall propose a project and schedule to reduce that CSO site or group of sites to or below its baseline condition;

(i) When a CSO site has been reduced to an average of one overflow per year through use of storage or separation, the department may consider reducing the monitoring requirement to frequency verification;

(ii) If the selected CSO control project is at-site treatment and discharge, the department may issue a modification to the applicable sewage treatment plant permit or issue a separate NPDES permit for that discharge. The permit or permit modification shall include effluent limits, flow capacity limits, and reporting requirements. The total treated and untreated annual discharge from an at-site treatment plant shall not increase above the baseline annual;

(b) Explains the previous year's CSO reduction accomplishments; and

(c) Lists the projects planned for the next year.

(2) In conjunction with its application for renewal of its applicable NPDES permit, the municipality shall submit an amendment to its CSO reduction plan. The amendment shall include:

(a) An assessment of the effectiveness of the CSO reduction plan to date; and

(b) A reevaluation of the CSO sites' project priority ranking; and

(c) A listing of projects to be accomplished in the next five years based upon priorities and estimated revenues. The department of ecology may incorporate such schedule into an administrative order or the applicable NPDES permit.

[Statutory Authority: RCW 90.48.035. 87-04-020 (Order DE 86-34), § 173-245-090, filed 1/27/87.]

Chapter 173-255 WAC

LIMITATIONS ON USE OF REFERENDUM 26 GRANT FUNDS FOR WATER POLLUTION ABATEMENT

Appendix B: King County Computer Modeling

1979 CSO Control Program

In this program, models specifically developed for the 1976 Metro 201 Facilities Plan were used. These included a model known as HYDRO to generate runoff from storms. HYDRO used a synthetic unit hydrograph technique to calculate surface runoff from rainfall. The synthetic unit hydrograph is a triangular hydrograph of the flow that would result from one inch of rain in a ten-minute period. Unit hydrograph shape was dependent on the shape of the area from which runoff was being calculated. Two sets of independent calculations were performed for impervious and pervious surfaces.

Sanitary sewage flows were represented in the 1979 modeling by diurnal hydrographs adjusted in magnitude based on the land use of individual tributary areas. A base infiltration factor (usually 1100 gpad but adjusted for measured flows) was added to compute base sewage flow. Runoff computed by the unit hydrograph technique was then added to base wastewater flows.

The total flow hydrographs computed in each basin of the system were routed through Metro's interceptors using a model known as "NETWORK." NETWORK was a specially developed model using a kinematic wave approximation to the full equations of motion. The kinematic wave approximation does not fully account for backwater effects from pump stations, regulator gates pipes with less capacity than the flow trying to enter them. Thus, a complete description of the system operation was not available (the actual impact of throttling back on the Interbay pump station could not be precisely simulated for example). Because flows from the north end of the West Point system were not large, these were simulated as a constant value in development of the 1979 Plan.

1986/88 CSO Plan

In the modeling effort for the 1986/88 CSO Plan, consultants used different programs to generate inflow hydrographs from the separated and combined portions of the service area. For the separated sewer area (upstream of the Lake City Regulator), the program LCHYD was used to generate flows from nine sub-basins. A diurnal base flow (e.g., showing two peaks within the same day) hydrograph was developed based on domestic/commercial and industrial populations. A linear relationship was assumed between rainfall and inflow, up to a maximum amount. Infiltration was assumed to be constant for the wet season. A maximum inflow value of 500 gallons per acre per day (gpad) was used for simulating future flows from currently non-sewered areas that were expected to develop and include sewers in the future.

The program LCPRE was used to take into account that peak flows do not occur at the same time in all parts of the system. This lag was incorporated into the simulation.

For the combined system, the program HYDRO72 was used to generate hydrographs from 19 basins in the Northern Service Area (NSA). This was a modification of the HYDRO program used in the 1979 CSO Control Program. Several of the basins in the HYDRO simulation were combined for use in the HYDRO72 model. Furthermore, the length of simulation was increased from 24 hours to 72 hours for HYDRO72, which allowed for longer storm events to be simulated.

The same basin parameters from the 1979 CSO Control Program effort were used in the 1986 effort. Despite concerns about the model, a decision was made to continue using the model for continuity with past planning. Five design storms were used to estimate annual CSO volumes and frequencies under existing (at that time) conditions and under future conditions.

The input hydrographs were then used as input to the SACRO (Seattle Area Central Routing Organization) simulation. SACRO simulated the routing of flow through the northern service area (NSA) of the wastewater system. It was designed to give reasonable estimates of the volume of flow through the NSA system. The flow from Interbay Pump Station was assumed to remain the same throughout the study period (1982 – 2030)

For the wet season, it was assumed that infiltration would remain the same as in the 1981-83 model calibration, at 1100 gpad. HYD72 (similar to HYDRO72) was used to generate synthetic unit hydrographs from 62 basins in the SSA. Seven design storms of varying length and intensities were used to estimate annual CSO frequencies and volumes for the SSA.

The Southern Service Area (SSA) large pipe flow was simulated using SSACRO (South Seattle Area Control Routing Organization). It was developed using primarily SACRO and some of NETWORK. It is based on level pool storage routing concepts and therefore does not accurately represent dynamic wave storage or routing. The program only calculated how the different input hydrographs travel through the system – combining at sewer junctions, splitting at diversions, etc. It did not simulate the reduction of flows at the Interbay Pump Station due to flows at the West Point treatment plant exceeding its setpoint which at that time was 325 million gallons per day.

SSACRO and SACRO basically added up all flows into a particular node (regulator, pump station, etc.), subtracted away that which could be hydraulically conveyed away from the node, and if anything was left, it was either stored or called an overflow. It is a mass balance model and did not compute water surface elevations in the collections system.

The program EBIPRE was developed to simplify and reduce the time involved in routing flows through the Elliott Bay Interceptor. It lagged inflow hydrographs and then combined them to be used in the routing model SSACRO. It also accounted for some of the City of Seattle CSOs and storage projects.

SACE (Seattle Area Combined Sewer Overflow Evaluator) was written to allow rapid testing of alternatives and to determine recurrence periods of overflows for design events. It calculated annual overflows for the wastewater system for the 1942-84 period. The

SACE program simply assigned portions of each rainfall event to 1) system capacity; 2) system storage; and 3) rainfall that couldn't get into the sewer. The amount of available storage was increased during inter-event periods to reflect the draining of wastewater from storage. For each rainfall event, the wastewater entering the sewer that could not be contained in "system capacity" or "system storage" was considered to be CSO. There was no simulation of the flow as it proceeded toward the treatment plant.

CATAD Program Improvements -- Predictive Control Program Begins

In 1986, a different approach was begun to model the West Point (combined) system, leaving behind the previous model. The effort was to support the development of an optimized real-time control program for the West Point collection system. The Predictive Control Program was to allow the Computer Augmented Treatment and Disposal System (CATAD) to automatically operate regulator gates and optimize in-line storage throughout the entire collection system to minimize CSOs.[1]

As part of this new approach, two new programs were developed to simulate flow through the West Point system. A kinematic wave runoff program was developed to simulate overland flow resulting from rainfall. Flow over both pervious and impervious areas that enters the sewer system was simulated. The West Point system was divided into over 400 basins to simulate this overland flow. This flow was then routed through a kinematic wave transport program, which effectively simulates the lagging and attenuation of flows through the local sewer pipes. The program also computes depths and velocities of flows in each pipe, and is a good approximation of actual conditions as long as there are no backwater effects or hydraulic transients (e.g., hydraulic phenomenon that are short in duration). Unlike previous programs used to model the wastewater, the runoff/transport program is a *physically-based* model that attempts to directly simulate the flow mechanics of the local sewer system. The program simulates a diurnal base domestic flow and a constant groundwater leakage. Inflow from rainfall-induced hydrographs were simulated and input into the appropriate pipes for routing.

Over 70 flowmeters were installed to calibrate the runoff/transport model in the late 1980s.

The model UNSTDY was obtained in 1986 from Colorado State University to route the runoff/transport flow hydrographs through the Metro/King County trunks and interceptor system. UNSTDY is a complex, fully dynamic simulation that computes flows, depths, and velocities in all pipes in the system. The full hydraulic equations are solved implicitly which enables it to simulate backwater effects, flow reversals, and gravity waves effectively. This sophistication was required to accurately simulate the in-line storage being utilized throughout the collection system. It was enhanced to simulate the operation of the regulator gates and pump stations.

UNSTDY was programmed to simulate the regulator system using local control (manual control), the existing Automatic Control, and the new Predictive Control. In early 1992,

[1] Automatic control by CATAD was implemented in 1974. Predictive Control optimizes it.

it was discovered that several of the level sensors (bubblers) were reading incorrectly, and probably had been since installation. The UNSTDY simulation was modified to be able to simulate control structures as they would have been operated if the sensors were reading incorrectly, as well as if they were reading correctly. This option (which simulates flow assuming errors in the levels sensors) is used when simulating conditions under "baseline" (1981-83) conditions.

The runoff/transport program was enhanced in the early 1990s to include rainfall-induced infiltration into the sewer system. This infiltration can be the largest component of I/I during large storms in the separated portion of the County sewer system. This modification allows King County to simulate the flow from the northern part of the West Point service area much more accurately than had been possible previously.

Regional Wastewater Services Plan

For the *1995 CSO Update*, the same seven design storms used in the 1988 plan were used to estimate annual CSO volumes. For the *2000 CSO Update*, 11-year continuous simulations were used to estimate CSO frequencies and volumes. As each flow transfer or CSO project is constructed, UNSTDY is modified to include that facility. For example, the Hanford/Lander Separation Project is included for simulations past 1990. The Carkeek flow transfer was included beginning in 1994. The Allentown Diversion was included in 1996. The Alki Flow transfer was included in 1998 as was the University CSO Project (Densmore Pump Station). For future years, the Denny Way CSO facility, the Harbor CSO transfer to the West Seattle Tunnel, and the Henderson/Martin Luther King Way CSO facility are being simulated.

CATAD Modifications

CATAD is continually modified to take into account advances in computer modeling as well as inputs of more recent field data. Since 1991, CATAD (which includes the Predictive Control Program) has been modified to include the following components:

1) Raising storage levels behind regulator stations
2) Lowering the wet well level at Interbay Pumping Station when rainfall was detected upstream, moving flow to the West Point Treatment Plant sooner and vacating storage space in the interceptor
3) Incorporating the Predictive Control Program which monitors rainfall and conditions in the major trunks and interceptors, predicts inflows to the sewer system, and optimizes the regulation of flow through the regulators to minimize CSOs.

When implemented and operating together as designed, the three components have been estimated to reduce CSO volumes by 150 million gallons per year. All three components have been completed. However, problems at Interbay Pump Station and with the computer hardware at West Point prevent the use of the second and third (Predictive Control) components. Improvements to the Interbay Pump Station are underway to ensure consistent successful operation of the pump station in "CSO mode" (lowering the wet well operating level) during storm events without entraining air into the pumps. Computer hardware and system software upgrades are being scheduled, which will enable operation of the Predictive Control Program. Modifications to the Predictive Control Program will be continually needed to incorporate new flow transfers and CSOs projects and to improve the efficiency and robustness of the optimization program.

Appendix C: Regional Wastewater Services Plan CSO Policies adopted by the King County Council November 1999

Ordinance No. 13680

Appendix D: Task 16.01 Tech Memo On Event Definition

(1) constructing large underground tanks and tunnels to store combined flows during storms. These flows would then be pumped to the west treatment plant once the rain subsides; and

(2) treating the combined sewage at existing CSO outfall locations using technology to remove solids and disinfect the combined sewage before discharge.

Refinements to the CSO program may be required in response to changing conditions and new information. The listing of species under the ESA may affect project priorities, schedule and associated mitigation options.

SECTION 8. **Combined sewer overflow control policies (CSOCP).** A. Explanatory material. The CSO control policies are intended to guide the county in controlling CSO discharges. Highest priority for controlling CSO discharges is directed at those that pose the greatest risk to human health, particularly at bathing beaches, and environmental health, particularly those that threaten species listed under ESA. The county will continue to work with federal, state and local jurisdictions on regulations, permits and programs related to CSOs and stormwater. The county will also continue its development of CSO programs and projects based on assessments of water quality and contaminated sediments.

B. Policies.

CSOCP-1: King County shall plan to control CSO discharges and to work with state and federal agencies to develop cost-effective regulations that protect water quality. King County shall meet the requirements of state and federal regulations and agreements.

CSOCP-2: King County shall give the highest priority for control to CSO discharges that have the highest potential to impact human health, bathing beaches and/or species listed under ESA.

CSOCP-3: Where King County is responsible for stormwater as a result of a CSO control project, the county shall participate with the city of Seattle in the municipal stormwater national pollutant discharge elimination system permit application process.

CSOCP-4: Although King County's wastewater collection system is impacted by the intrusion of clean stormwater, conveyance and treatment facilities shall not be designed for the interception, collection and treatment of clean stormwater.

CSOCP-5: King County shall accept stormwater runoff from industrial sources and shall establish a fee to capture the cost of transporting and treating this stormwater. Specific authorization for such discharge is required.

CSOCP-6: King County, in conjunction with the city of Seattle, shall implement stormwater management programs in a cooperative manner that results in a coordinated joint effort and avoids duplicative or conflicting programs.

CSOCP-7: King County shall develop a long-range sediment management strategy to prioritize clean up of contaminated sediments at specific CSO locations.

CSOCP-8: King County shall use the results of the 1998 water quality assessment to assess CSO control projects and priorities before issuing the year 2000 CSO update required by the county's national pollutant discharge elimination system permit. Prior to the year 2005 CSO update, the executive shall evaluate the benefits of CSO control projects along with other pollution control projects developed by King County and other agencies. This CSO program review will include, but not be limited to the following: maximizing use of existing CSO control facilities; identifying the public and environmental health benefits of continuing the CSO control program; ensuring projects are in compliance with new regulatory requirements and objectives such as the ESA and the Wastewater Habitat Conservation Plan; analyzing rate impacts; ensuring that the program review will honor and be consistent with long-standing existing commitments; assessing public opinion; and integrating the CSO control program with other water/sediment quality improvement programs for the region. Based on its consideration of the CSO program review, the RWQC may make recommendations for modifying or amending the CSO program to the council.

CSOCP-9: Unless specifically approved by the council, no new projects shall be undertaken by the county until the CSO program review has been presented to the council for its consideration. CSO project approval prior to completion of CSO program review (beyond those authorized in this subsection) may be granted based on, but not limited to, the following: availability of grant funding; opportunities for increased cost-effectiveness through joint projects with other agencies; ensuring compliance with new regulatory requirements; or responding to emergency public health situations. The council shall request advice from the RWQC when considering new CSO projects. King County shall continue implementation of CSO control projects underway as of the effective date of this section, which are the Denny way, Henderson/Martin Luther King, Jr. way/Norfolk, Harbor and Alki CSO treatment plants.

Section 18: Implementation

4. CSOs.

a. CSO projects shall be prioritized based on first controlling discharges that impact bathing beaches and species listed under ESA. The second priority is other CSO locations that have the potential to affect public health and safety. Third priority are all other CSO locations. The estimated cost for CSO control projects is 220 million dollars, 1998 net present value. These project areas should be completed on the following schedule:

Priority	Project areas and projects	Completion period
1	Puget Sound beaches Norfolk 0.8 million gallon (MG) storage tank South Magnolia 1.3 MG storage tank SW Alaska 0.7 MG storage tank Murray 0.8 MG storage tank Barton Pump Station (PS) Upgrade North Beach storage tank & PS upgrade	2009-2011
2	Lake Washington ship canal, east side University/Montlake 7.5 MG storage tank	2015
3	Duwamish River and Elliott Bay shoreline Hanford #2 3.3 MG storage/treatment tank Lander 1.5 MG storage/treatment tank Michigan 2.2 MG storage/treatment tank Brandon 0.8 MG storage/treatment tank Chelan 4.0 MG storage tank Connecticut 2.1 MG storage/treatment tank King Street conveyance to Connecticut Hanford at Rainier 0.6 MG storage tank 8th Ave. S 1.0 MG storage tank W Michigan conveyance expansion Terminal 115 0.5 MG storage tank	2017-2027
4	Lake Washington ship canal, west side Ballard 1.0 MG storage tank 3rd Ave W 5.0 MG storage tank 11th Ave NW 2.0 MG storage tank	2029-2030
Other	West treatment plant - primary and secondary treatment enhancements to handle increased flows from CSO projects	2018

b. The CSO projects may include:

DRAFT TECHNICAL MEMORANDUM

Date: September 21, 1995 014/7683-24

Prepared by: Andy Lukas, Steve Merrill, Brown and Caldwell

Subject: CSO Event Definition -- 5 Year Update Task 16.01

Executive Summary

Task 16.01 of the CSO Update Contract calls for a definition of a CSO event based on recognized statistical analyses. The goal of this task of the CSO contract is to define an interevent period between CSO events which insures that individual events are statistically independent of each other. The interevent period is the dry time between overflows, and determines the number of overflows occurring per year in the Metro system. This memorandum describes the foundation for the analysis, sources of data, analysis procedures, and results of this analysis.

Forty six and one half years of rainfall data from the Seattle-Tacoma Airport NOAA gauge were analyzed to establish a minimum interevent period (dry period between individual rainfall events) necessary to establish statistical independence of storms. This analysis indicated the minimum interevent period to be 15 hours in the winter season (November through April), and to be 33 hours in the summer season (May through October). Because of the difficulties of working with significantly different periods in different seasons, an average annual value of 18 hours is recommended. There is little error in this approach.

The minimum interevent period to establish statistically independent CSO events is not necessarily the same as for rainfall, although obviously related. This is because the variation in rainfall intensities within a single long rainfall event may result in multiple occurrences of overflow which may be separated by periods exceeding the minimum rainfall interevent period. However, a basic assumption of this analysis is that a single independent rainfall event must produce only one CSO event. The problem of multiple overflow occurrences would be avoided if event reporting were based on rainfall. It is expected, however that the Washington Department of Ecology will specify an interevent period that is related to the occurrence of overflow rather than rainfall as was done in the Carkeek interim discharge permit, thus requiring definition of a CSO specific interevent period. Flow data is more reliable, more readily available, and site specific than rainfall.

Determination of a CSO specific interevent period involves finding the period that results in the same total number of CSO events in the record as there are independent rainfall

events that produce some overflow. By analyzing the rainfall record together with a simulated overflow history at the Martin Luther King Way overflow produced by that record, it was determined that a minimum CSO interevent period of 40 hours is appropriate. For convenience, a CSO interevent period of 48 hours is suggested--matching that specified by the Washington Department of Ecology in the interim Carkeek permit. Using this definition, a CSO event will have been considered to end only after 48 hours has elapsed since the last measured occurrence of overflow.

Purpose and Background

The interevent period is the dry time between occurrences of rainfall or combined sewer overflow. The interevent period is used to separate events for counting--in other words, if one begins counting hours immediately after rainfall or overflow ceases, the interevent period is the number of dry hours before rainfall or overflow occurs again. Rainfall events in the northwest are typically the result of cyclonic weather patterns associated with the passage of a low pressure zone over the area of interest. The general pattern is complicated by the so-called 'convergence zone' effect wherein winds from the ocean split storms around the Olympic Peninsula and create a zone of heavier rainfall when they recombine in the Puget Sound Lowlands. As a result of these patterns, local rainfall events may range from a constant drizzle, to a steady downpour, to a series of rainfall bursts separated by a few hours of dry windy weather. The latter pattern is common, and is the most important for CSO Control. The rainfall bursts are not independent, but they may result in overflows that cease during the intervening dry periods. Both the rainfall and CSO bursts cannot be counted as individual events. It is necessary to resort to statistical methods to find the average interevent period to separate both rainfall and CSO occurrences into independent events. Otherwise, there is the risk that arbitrary selection of too short a period would result in the counting of too many events--an important issue given the Washington Department of Ecology's (Ecology) requirement for eventual control of each CSO location to an average of one event per year.

Ecology has no defined criteria for defining storms or CSO events. In preparation of the 1988 CSO Control Plan, Technical Memoranda prepared for Metro mention the use of a dry CSO interevent period of three hours. This value was apparently taken from previous use by Metro in CATAD reports. Parallel work for the City of Seattle in preparation of their CSO Control Plan suggested that a 24 hour interevent period was appropriate. Subsequent work for the Carkeek Transfer Facilities Plan also used a 24 hour interevent period in analysis of treatment performance. Ecology subsequently specified 48 hours as an interevent period in the Carkeek discharge permit. Extensive analysis of rainfall in Portland led to a 24 hour interevent period definition. Past work has suggested that the three hour interevent period is too short, potentially leading to more costly CSO control facilities than necessary. Thus, this task was established to provide a method for defining rainfall and CSO events this is objective, is consistent with established statistical hydrology, and is based on local rainfall patterns.

Foundation of Analysis

Two basic assumptions underlie this analysis:

- One rainfall event causes only one CSO event. If a rainfall event, by having varying intensities through the storm, causes intermittent discharges from a CSO location, those intermittent discharges are considered to be a single CSO event.
- Rainfall events must be statistically independent. In other words, there is no joint probability linking one event to another. The standard method of establishing events is to separate the historical record into separate periods between which there is a minimum dry period necessary to establish independence.

Two sources of information were used to establish an approach for determining the proper interevent period. First, Restrepo-Posada and Eagleson (1982) recommend a methodology for identifying the interevent period for segregating statistically-independent storms from a large data series. Second, Adderley (1994) describes how rainfall was analyzed for the City of Portland CSO Management Study.

The Restrepo-Posada paper and the Portland study used a similar approach to identifying the interevent period. The basis for both was that the interevent period should be set to that which ensures statistical independence of events in the data set. That is, when identifying the rainfall event with this interevent duration of X hours, all storm events are separated by at least X hours and they are statistically independent. The basis for this definition is that rainfall is a Poisson process whose data set is exponentially-distributed. Statistical independence of events which are exponentially-distributed is achieved when the coefficient of variation of the interevent periods is equal to 1.0. In essence, this means that the standard deviation of the interevent periods found in a record of independent rainfall events is equal to the mean of the interevent periods.

An additional criteria is applied to insure that the events so specified do not overlap. Overlapping of individual events is prevented by insuring that the ratio of event duration to the inter-arrival time (the sum of the storm duration and the subsequent dry period before the next storm) is much less than 1.0.

Sources of Data

Metro supplied 46.5 years of rainfall representing the SeaTac International Airport record. With this rainfall, they produced and supplied a simulated record of overflow from the Martin Luther King Way CSO (MLK Way). The rainfall record starts on July 4, 1948 at 4:00 am and continues until January 29, 1995, at 11:09 am. The first CSO event begins on July 27, 1948, at 7:50 am; the last CSO event ends on December 27, 1994, at 7:30 am.

Analysis Procedures

Specialized computer programs were written to read and summarize the data into events. The program reads through the record counting and summing rainfall or CSO hours and volume and dry hours separately. If rainfall or CSO has not occurred for a pre-specified interevent time, then the program counts the proceeding rainfall or CSO as a separate event, and summing begins for the next event. Rainfall and CSO time series were analyzed with minimum interevent durations of 3 to 168 hours. Using the results, frequency distributions were developed for:

1. Overflow volume vs. overflow duration.
2. Overflow volume vs. number of events per calendar year.
3. Overflow volume vs. number of events per water year.
4. Rainfall depth vs. rainfall duration.

The results were also loaded into a database and summary statistics were produced, grouping on months and seasons. The "Winter" season was defined as November through April, and "Summer" season was defined as May through October. Summaries (attached as appendices to this memorandum) were compiled for:

1. Total number of events,
2. Number of events per year,
3. Overflow volume during event (maximum, average, standard deviation, and coefficient of variation),
4. Maximum overflow rate during an event (maximum, average, standard deviation, and coefficient of variation),
5. Overflow duration (average, standard deviation, and coefficient of variation),
6. Interevent duration following the overflow event (average, standard deviation, and coefficient of variation),
7. Rainfall depth during event (maximum, average, standard deviation, and coefficient of variation),
8. Rainfall event duration (average, standard deviation, and coefficient of variation),
9. Interevent duration following the rainfall event (average, standard deviation, and coefficient of variation.

Rainfall Analysis

As noted previously, the minimum interevent period that should be used to separate a data series into statistically independent events is that period that results in the average of all interevents in the record to be equal to the standard deviation of the interevents in the record. Determination of this value involves iterative analysis in which a minimum interevent period is selected, and the record divided into individual events using this interevent period. The record (consisting of date, time of day and corresponding rainfall depth) is read by a program which simply keeps track of the number of hours of dry and wet time as it sequentially moves through the record. The event is not considered complete until at least the specified interevent period has passed without rainfall. When this occurs, the program counts an event, sums the rainfall depth and duration, and sums the number of dry hours that occurred between the last rainfall occurrence in the event and the first rainfall occurrence in the next event. The duration of each separate rainfall event and its corresponding interevent period are placed in a database for later analysis. After proceeding through all the record, summary statistics are computed and compared to the independence criteria. Standard practice dictates that the statistics be developed for monthly, seasonal and annual periods.

For rainfall, it was found that an interevent period of 15 hours in the winter resulted in a Coefficient of Variation of 1.0, and 33 hours was necessary in the summer. Using these interevent periods, the winter and summer rainfall event statistics are shown in Table 1.

Table 1. Rainfall Event Statistics

Statistic	Winter Events	Summer Events
Minimum interevent period, hours	15	33
Average number of events per year	55	25
Average rainfall depth, inch	0.47	0.40
Average intensity, inch/hour	0.02	0.01
Average event duration, hours	21	28
Average time between events, hours	57	151
Overlapping Ratio	0.35	0.16

The average statistics presented in Table 1 are similar to results of the analysis for Portland, Oregon (Adderly, 1994). In the Portland study, the minimum interevent period was found to be 18 hours in the winter and 48 hours in the summer with somewhat greater storm durations and depths. Because of the difficulties in using different minimum interevent definitions for winter and summer, the Portland study recommended use of a single annual value of 24 hours. Based on review of the results of this analysis, there would be little loss of statistical reliability if a similar approach were used for the Seattle case. For Seattle data, an annual average minimum interevent period for rainfall analysis of 18 hours is more appropriate, however.

CSO Analysis

The straightforward way to apply the interevent statistics to CSO event definition is to use the average annual value of 18 hours for rainfall events, and assume a CSO event has not ended until 18 hours with no rainfall has occurred. This requires that the rainfall data from many different raingauges be analyzed and presented in annual reports to Ecology. However, overflow data from CSO control facilities will be more reliable than rainfall as well as more readily available. In addition, the current Carkeek discharge permit is written to use a 48 hour interevent period between actual discharges without regard to the causative rainfall. It is to be expected that a similar approach will be taken in future permits because it is easier to compile and review. Thus, it is necessary to define a minimum interevent period that is specific to CSO discharges rather than rainfall.

For CSOs, the results from the rainfall analysis are not meaningful. Because rainfall will vary during an event, there may be several periods of overflow associated with one rainfall event. In addition, overflow my continue beyond the cessation of rainfall due to rainfall dependent infiltration in the system or the travel time down the sewer network. Definition of the appropriate CSO interevent period is accomplished by seeking a period that produces the same number of overflow events in the CSO record as there are rainfall events that produce some overflow.

By taking the average annual minimum interevent criterion of 18 hours for rainfall and CSOs, the number of rainfall events causing CSOs at the MLK Way overflow was counted. Counting the CSO-causing rainfall events like this allows more than one CSO occurrence within a single rainfall event. An example of this is provided in Figure 1. If the minimum interevent time specified were 3 hours, the rain time series shown in Figure 1 is considered one event. However, the CSO time series would be considered two events. By examining the CSO time series with respect to the rainfall time series, the portion of the CSO time series shown in Figure 1 would be considered one CSO event.

Analysis of the rainfall data with a 18 hour minimum interevent duration identified 3805 rainfall events of which 802 caused overflow as shown in Table 2. The same 18 hour interevent duration identified 943 CSO events. The minimum CSO interevent time required to identify the same number of CSO events as rainfall events causing CSOs (802) lies between 36 and 48 hours or at about 40 hours. For convenience, a CSO interevent period of 48 hours is recommended. This is consistent with the interevent period specified by Ecology in the interim Carkeek permit.

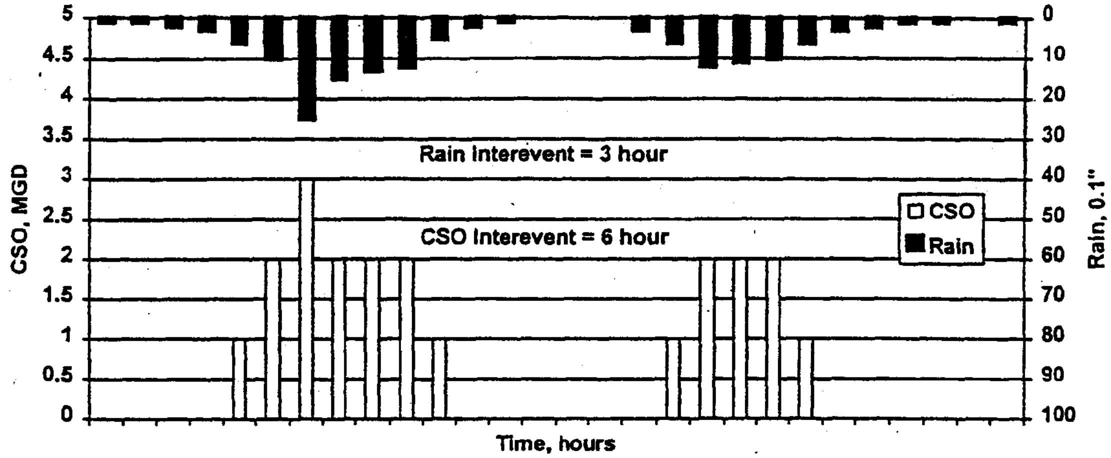

Figure 1. Comparison of Rainfall and CSO Interevent Periods.

References

Restrepo-Posada, P.J. and Eagleson, P.S. *Identification of Independent Rainstorms.* Journal of Hydrology, 55 (1982), pp. 303-319.

Adderley, V. *TM 7.1: Rainfall Analysis for CSO Facilities Planning.* Portland CSO Management Study Task 5.2 (Phase 2), (March 23, 1994), pp. 7.1-1 to 7.1-44.

Table 2. Interevent Analysis Results--MLK Way CSO and SeaTac Airport Rainfall

Interevent	MLK Overflow		Seatac Rainfall			Rainfall Events Causing Overflow	
eriod. hrs	# of Events	Events/Year	# of Events	Events/Year	inter C.V.	# of Events	Events/Year
3	1196	25.72	9458	203.40	1.63	1048	22.54
6	1103	23.72	6668	143.40	1.32	961	20.67
9	1047	22.52	5448	117.16	1.17	900	19.35
12	999	21.48	4706	101.20	1.07	862	18.54
15	967	20.80	4202	90.37	1.00	836	17.98
18	**943**	**20.28**	**3805**	**81.83**	**0.94**	**802**	**17.25**
24	884	19.01	3216	69.16	0.85	742	15.96
30	849	18.26	2744	59.01	0.78	687	14.77
33	821	17.66	2555	54.95	0.75	660	14.19
36	**821**	17.66	2409	51.81	0.73	639	13.74
48	771	16.58	1904	40.95	0.63	571	12.28
60	725	15.59	1533	32.97	0.57	497	10.69
72	679	14.60	1311	28.19	0.52	450	9.68
84	633	13.61	1138	24.47	0.49	408	8.77
96	600	12.90	999	21.48	0.46	379	8.15
120	559	12.02	751	16.15	0.41	314	6.75
144	527	11.33	589	12.67	0.39	270	5.81
168	485	10.43	475	10.22	0.38	224	4.82

3 Hour Rainfall Interevent Statistics (Summary)

11-Jul-95

Month	Event		Depth (in)				Duration (hrs)				Interevent Duration			
	Total	#/Year	Max	Avg.	St. Dev.	C.V.	Max	Avg.	St. Dev.	C.V.	Max	Avg.	St. Dev.	C.V.
January	1172	25.2	3.36	0.21	0.37	1.72	43.00	5.41	6.78	1.25	360.07	24.41	40.76	1.67
February	953	20.5	3.08	0.19	0.32	1.67	52.67	5.01	6.45	1.29	402.00	27.41	45.40	1.66
March	1062	22.8	3.10	0.15	0.23	1.54	33.67	4.41	5.25	1.19	465.00	27.69	45.19	1.63
April	897	19.3	4.79	0.12	0.23	1.92	49.50	3.36	4.28	1.27	508.12	35.01	55.97	1.60
May	631	13.6	2.41	0.12	0.20	1.70	39.00	3.17	4.27	1.35	721.10	54.01	85.90	1.59
June	499	10.7	2.14	0.13	0.22	1.67	39.75	3.25	4.27	1.31	966.33	66.45	119.03	1.79
July	291	6.3	0.85	0.12	0.16	1.33	25.00	2.92	3.66	1.25	039.33	133.12	208.20	1.56
August	371	8.0	1.75	0.13	0.21	1.70	21.00	2.95	3.68	1.24	093.03	77.71	135.45	1.74
September	543	11.7	2.20	0.15	0.24	1.62	33.80	3.29	4.15	1.26	008.98	58.69	111.54	1.90
October	793	17.1	2.73	0.18	0.27	1.44	43.00	4.19	4.84	1.16	433.50	35.12	52.49	1.49
November	1078	23.2	3.87	0.24	0.39	1.64	48.75	5.39	6.70	1.24	384.50	24.95	38.33	1.54
December	1168	25.1	4.44	0.22	0.38	1.73	62.50	5.20	6.80	1.31	530.00	25.61	39.90	1.56
Total	9458	203.40												

6 Hour Rainfall Interevent Statistics (Summary)

11-Jul-95

Month	Event		Depth (in)				Duration (hrs)				Interevent Duration			
	Total	#/Year	Max	Avg.	St. Dev.	C.V.	Max	Avg.	St. Dev.	C.V.	Max	Avg.	St. Dev.	C.V.
January	778	16.7	3.46	0.33	0.52	1.59	104.50	10.32	13.12	1.27	360.07	34.67	46.72	1.35
February	660	14.2	4.03	0.27	0.43	1.60	90.00	8.86	10.83	1.22	402.00	37.71	51.30	1.36
March	711	15.3	3.10	0.23	0.34	1.47	79.80	8.61	10.09	1.17	465.00	39.42	51.34	1.30
April	625	13.4	4.80	0.17	0.29	1.68	52.50	6.49	7.65	1.18	508.12	48.48	62.43	1.29
May	481	10.3	2.41	0.15	0.23	1.51	40.67	5.42	6.48	1.20	721.10	69.66	93.05	1.34
June	397	8.5	2.14	0.16	0.26	1.60	58.75	5.09	6.50	1.28	966.33	82.39	128.70	1.56
July	236	5.1	0.97	0.14	0.19	1.31	38.00	4.52	5.96	1.32	039.33	163.18	220.66	1.35
August	277	6.0	1.75	0.17	0.27	1.58	49.90	5.45	6.91	1.27	093.05	102.80	148.67	1.45
September	393	8.5	2.54	0.20	0.31	1.53	48.80	5.93	7.34	1.24	009.00	79.55	124.98	1.57
October	565	12.2	3.98	0.26	0.37	1.42	54.87	7.55	8.82	1.17	433.50	47.88	57.64	1.20
November	756	16.3	3.87	0.34	0.49	1.45	77.00	9.46	10.75	1.14	384.50	33.82	42.65	1.26
December	789	17.0	4.44	0.32	0.48	1.48	62.87	9.61	10.74	1.12	530.00	35.97	45.08	1.25
Total	6668	143.40												

9 Hour Rainfall Interevent Statistics (Summary)

11-Jul-95

Month	Event		Depth (in)				Duration (hrs)				Interevent Duration			
	Total	#/Year	Max	Avg.	St. Dev.	C.V.	Max	Avg.	St. Dev.	C.V.	Max	Avg.	St. Dev.	C.V.
January	602	12.9	4.03	0.42	0.63	1.49	131.80	15.49	18.69	1.21	360.07	43.03	50.55	1.17
February	524	11.3	4.35	0.34	0.51	1.52	92.90	13.06	15.71	1.20	402.00	45.67	54.73	1.20
March	571	12.3	3.10	0.28	0.39	1.39	92.75	12.38	14.52	1.17	465.00	47.10	54.34	1.15
April	508	10.9	4.80	0.21	0.33	1.57	68.33	9.62	10.84	1.13	508.12	57.90	65.72	1.14
May	411	8.8	2.41	0.18	0.26	1.44	48.87	7.54	9.00	1.19	721.10	80.21	96.79	1.21
June	337	7.2	2.15	0.19	0.28	1.49	67.75	7.30	8.98	1.23	966.33	96.15	135.32	1.41
July	212	4.6	0.97	0.16	0.20	1.23	41.67	5.80	7.51	1.30	039.33	180.27	226.44	1.26
August	237	5.1	1.75	0.20	0.30	1.46	52.90	7.69	9.21	1.20	093.05	119.34	154.89	1.30
September	322	6.9	2.82	0.25	0.37	1.48	61.90	9.00	11.13	1.24	009.00	95.39	132.88	1.39
October	464	10.0	3.98	0.32	0.43	1.37	100.00	10.81	12.94	1.20	433.50	56.81	60.05	1.06
November	619	13.3	4.36	0.42	0.58	1.39	122.00	13.16	15.22	1.16	384.50	40.00	45.18	1.13
December	641	13.8	4.44	0.39	0.57	1.45	122.00	13.34	15.72	1.18	530.00	42.21	47.51	1.13
Total	5448	117.16												

12 Hour Rainfall Interevent Statistics (Summary)

11-Jul-95

Month	Event		Depth (in)				Duration (hrs)				Interevent Duration			
	Total	#/Year	Max	Avg.	St. Dev.	C.V.	Max	Avg.	St. Dev.	C.V.	Max	Avg.	St. Dev.	C.V.
January	511	11.0	4.86	0.50	0.72	1.43	160.50	20.03	23.26	1.16	360.07	49.19	53.84	1.09
February	447	9.6	4.48	0.39	0.56	1.42	110.00	17.18	19.61	1.14	402.00	51.62	55.79	1.08
March	480	10.3	3.36	0.34	0.45	1.35	119.00	16.57	19.77	1.19	465.00	53.59	56.52	1.05
April	432	9.3	5.00	0.24	0.38	1.56	103.98	13.09	16.02	1.22	508.12	66.82	68.21	1.02
May	369	7.9	2.41	0.20	0.27	1.37	67.00	9.46	11.03	1.17	721.10	87.57	98.95	1.13
June	314	6.8	2.15	0.21	0.30	1.47	67.75	8.63	10.76	1.25	966.33	102.92	138.18	1.34
July	192	4.1	0.98	0.17	0.21	1.21	56.00	7.28	9.30	1.28	039.33	196.96	231.30	1.17
August	214	4.6	3.11	0.22	0.34	1.54	74.67	9.63	12.10	1.26	093.05	131.06	158.62	1.21
September	280	6.0	3.10	0.29	0.40	1.41	92.67	11.93	14.75	1.24	009.00	108.70	137.97	1.27
October	405	8.7	3.98	0.36	0.47	1.30	111.00	13.85	16.18	1.17	433.50	63.45	61.22	0.96
November	518	11.1	4.43	0.50	0.68	1.34	145.00	18.00	21.39	1.19	384.50	45.86	47.15	1.03
December	544	11.7	4.81	0.46	0.66	1.43	158.80	17.40	21.47	1.23	530.00	48.07	49.77	1.04
Total	4706	101.20												

15 Hour Rainfall Interevent Statistics (Summary)

17-Jul-95

Month	Event		Depth (in)				Duration (hrs)				Interevent Duration			
	Total	#/Year	Max	Avg.	St. Dev.	C.V.	Max	Avg.	St. Dev.	C.V.	Max	Avg.	St. Dev.	C.V.
January	434	9.3	4.87	0.59	0.82	1.39	195.00	26.07	30.09	1.15	360.07	56.07	56.53	1.01
February	394	8.5	4.54	0.44	0.62	1.39	120.50	21.07	23.44	1.11	402.00	56.21	57.02	1.01
March	428	9.2	3.36	0.38	0.50	1.32	150.67	20.48	24.87	1.21	465.00	59.19	58.25	0.98
April	386	8.3	5.00	0.27	0.41	1.52	121.50	15.81	19.38	1.23	508.12	72.37	69.40	0.96
May	332	7.1	2.41	0.22	0.29	1.31	76.75	12.15	13.55	1.12	721.10	96.13	100.85	1.05
June	290	6.2	2.15	0.22	0.32	1.42	96.00	10.31	12.60	1.22	966.33	109.99	141.44	1.29
July	182	3.9	0.98	0.18	0.22	1.19	56.00	8.42	11.00	1.31	039.33	207.05	233.43	1.13
August	195	4.2	3.11	0.25	0.38	1.54	82.80	11.88	15.63	1.32	093.05	142.52	161.67	1.13
September	259	5.6	3.25	0.31	0.45	1.45	93.98	13.95	17.92	1.28	009.00	116.45	140.64	1.21
October	372	8.0	3.98	0.39	0.52	1.33	161.50	16.40	20.52	1.25	433.50	68.22	61.81	0.91
November	459	9.9	4.43	0.57	0.74	1.29	204.80	22.37	26.62	1.19	384.50	50.01	48.53	0.97
December	471	10.1	5.35	0.53	0.75	1.43	219.50	21.87	27.35	1.25	530.00	53.26	51.48	0.97
Total	4202	90.37												

18 Hour Rainfall Interevent Statistics (Summary)

11-Jul-95

Month	Event		Depth (in)				Duration (hrs)				Interevent Duration			
	Total	#/Year	Max	Avg.	St. Dev.	C.V.	Max	Avg.	St. Dev.	C.V.	Max	Avg.	St. Dev.	C.V.
January	376	8.1	5.90	0.68	0.98	1.43	298.00	32.71	39.03	1.19	360.07	61.96	58.23	0.94
February	332	7.1	5.83	0.53	0.73	1.38	230.28	28.19	33.48	1.19	402.00	64.34	59.52	0.93
March	384	8.3	3.36	0.42	0.54	1.30	170.82	24.30	29.73	1.22	465.00	63.70	59.30	0.93
April	361	7.8	5.00	0.29	0.43	1.48	121.50	17.96	21.31	1.19	508.12	76.03	70.16	0.92
May	312	6.7	2.41	0.24	0.30	1.28	90.87	14.08	15.38	1.09	721.10	101.89	101.95	1.00
June	272	5.8	2.15	0.24	0.33	1.39	96.00	12.01	15.39	1.28	966.33	116.02	143.84	1.24
July	172	3.7	0.99	0.19	0.23	1.17	56.00	9.80	12.93	1.32	039.33	217.96	235.48	1.08
August	186	4.0	3.11	0.26	0.39	1.51	82.80	13.23	16.77	1.27	093.05	148.95	163.11	1.10
September	239	5.1	3.25	0.33	0.48	1.43	119.67	16.39	20.59	1.26	009.00	124.13	143.36	1.15
October	342	7.4	3.98	0.43	0.56	1.31	189.50	19.35	24.05	1.24	433.50	72.84	62.38	0.86
November	409	8.8	5.18	0.65	0.81	1.24	204.80	27.47	31.43	1.14	384.50	54.21	49.83	0.92
December	420	9.0	7.81	0.59	0.84	1.43	305.50	26.21	32.69	1.25	530.00	57.94	52.96	0.91

Total	3805	81.83

24 Hour Rainfall Interevent Statistics (Summary)

11-Jul-95

Month	Event		Depth (in)				Duration (hrs)				Interevent Duration			
	Total	#/Year	Max	Avg.	St. Dev.	C.V.	Max	Avg.	St. Dev.	C.V.	Max	Avg.	St. Dev.	C.V.
January	304	6.5	5.96	0.85	1.18	1.38	422.93	46.01	57.45	1.25	360.07	72.85	61.22	0.84
February	268	5.8	5.83	0.65	0.88	1.35	299.25	39.00	46.03	1.18	402.00	74.40	61.40	0.83
March	318	6.8	3.36	0.49	0.63	1.28	208.00	33.15	39.64	1.20	465.00	72.92	62.70	0.86
April	313	6.7	5.00	0.33	0.47	1.42	138.47	23.82	27.53	1.16	508.12	83.35	70.78	0.85
May	279	6.0	2.41	0.26	0.32	1.22	115.50	18.17	20.06	1.10	721.10	111.45	103.74	0.93
June	238	5.1	2.15	0.27	0.35	1.31	129.00	16.54	19.83	1.20	966.33	130.77	149.19	1.14
July	160	3.4	0.99	0.21	0.24	1.15	65.92	11.79	14.56	1.23	039.33	231.01	238.14	1.03
August	171	3.7	3.11	0.29	0.43	1.50	123.80	16.79	21.06	1.25	093.05	161.94	164.58	1.02
September	209	4.5	3.25	0.38	0.53	1.39	139.00	21.52	25.58	1.19	009.00	138.25	147.78	1.07
October	292	6.3	5.00	0.50	0.68	1.36	210.75	25.99	33.14	1.28	433.50	81.30	63.35	0.78
November	338	7.3	5.82	0.81	0.96	1.18	312.00	39.85	45.03	1.13	384.50	61.97	51.79	0.84
December	326	7.0	8.56	0.73	1.03	1.41	305.50	38.15	45.37	1.19	530.00	68.22	55.93	0.82
Total	3216	69.16												

30 Hour Rainfall Interevent Statistics (Summary)

11-Jul-95

Month	Event		Depth (in)				Duration (hrs)				Interevent Duration			
	Total	#/Year	Max	Avg.	St. Dev.	C.V.	Max	Avg.	St. Dev.	C.V.	Max	Avg.	St. Dev.	C.V.
January	246	5.3	7.02	1.05	1.47	1.40	559.00	63.24	82.35	1.30	360.07	83.98	64.18	0.76
February	219	4.7	5.83	0.78	0.99	1.27	299.25	52.68	57.83	1.10	402.00	84.94	62.40	0.73
March	269	5.8	3.36	0.58	0.70	1.21	218.00	43.79	50.87	1.16	465.00	81.62	64.67	0.79
April	266	5.7	5.12	0.39	0.54	1.38	259.00	32.78	39.35	1.20	508.12	95.75	78.14	0.82
May	247	5.3	2.41	0.29	0.34	1.17	175.50	23.23	25.80	1.11	721.10	118.76	102.01	0.86
June	212	4.6	2.15	0.30	0.37	1.24	129.00	21.58	23.56	1.09	966.33	143.39	153.40	1.07
July	150	3.2	1.34	0.22	0.26	1.19	115.00	14.40	19.11	1.33	039.33	244.59	239.89	0.98
August	156	3.4	3.11	0.32	0.46	1.47	136.50	20.90	25.34	1.21	093.05	175.02	166.57	0.95
September	184	4.0	3.25	0.44	0.57	1.30	190.00	28.80	34.15	1.19	009.00	153.86	151.00	0.98
October	260	5.6	5.50	0.57	0.76	1.33	220.50	33.44	41.85	1.25	433.50	88.39	63.92	0.72
November	262	5.6	6.63	1.06	1.18	1.11	363.00	59.66	66.46	1.11	384.50	72.26	54.53	0.75
December	273	5.9	8.65	0.88	1.18	1.35	322.00	50.62	59.73	1.18	530.00	76.34	57.65	0.76
Total	2744	59.01												

33 Hour Rainfall Interevent Statistics (Summary)

21-Sep-95

Month	Event		Depth (in)				Duration (hrs)				Interevent Duration			
	Total	#/Year	Max	Avg.	St. Dev.	C.V.	Max	Avg.	St. Dev.	C.V.	Max	Avg.	St. Dev.	C.V.
January	222	4.8	7.78	1.17	1.60	1.36	559.00	73.87	94.87	1.28	360.07	91.80	67.40	0.73
February	198	4.3	5.83	0.87	1.06	1.23	309.00	61.34	66.12	1.08	402.00	88.11	60.06	0.68
March	247	5.3	3.38	0.62	0.76	1.22	338.00	49.83	58.74	1.18	465.00	85.79	65.83	0.77
April	256	5.5	5.12	0.41	0.55	1.35	259.00	35.26	40.92	1.16	508.12	98.29	78.57	0.80
May	236	5.1	2.41	0.31	0.36	1.19	200.80	25.76	29.81	1.16	721.10	122.84	102.56	0.83
June	200	4.3	2.15	0.32	0.39	1.21	129.00	24.77	26.75	1.08	966.33	150.11	155.41	1.04
July	145	3.1	1.34	0.23	0.27	1.18	115.00	15.97	22.83	1.43	1039.33	251.95	240.64	0.96
August	145	3.1	3.11	0.34	0.48	1.41	140.90	25.48	28.91	1.13	1093.05	186.11	167.67	0.90
September	177	3.8	3.25	0.45	0.58	1.29	190.00	30.66	36.25	1.18	1009.00	158.55	152.06	0.96
October	244	5.2	5.50	0.64	0.85	1.33	330.75	39.91	52.31	1.31	433.50	93.09	63.94	0.69
November	237	5.1	6.63	1.14	1.23	1.08	363.00	67.36	72.59	1.08	384.50	75.96	55.54	0.73
December	248	5.3	8.65	0.96	1.30	1.35	372.98	59.00	71.09	1.21	530.00	80.93	58.66	0.72
Total	2555	54.95												

36 Hour Rainfall Interevent Statistics (Summary)

11-Jul-95

Month	Event		Depth (in)				Duration (hrs)				Interevent Duration			
	Total	#/Year	Max	Avg.	St. Dev.	C.V.	Max	Avg.	St. Dev.	C.V.	Max	Avg.	St. Dev.	C.V.
January	208	4.5	7.78	1.25	1.65	1.32	559.00	80.96	99.47	1.23	360.07	95.63	67.87	0.71
February	185	4.0	5.83	0.93	1.15	1.23	365.00	68.56	75.25	1.10	402.00	91.96	60.30	0.66
March	231	5.0	4.00	0.66	0.80	1.20	338.00	55.12	63.79	1.16	465.00	89.08	66.64	0.75
April	242	5.2	5.12	0.44	0.59	1.35	295.00	40.23	47.78	1.19	508.12	102.04	79.21	0.78
May	225	4.8	2.41	0.31	0.36	1.16	200.80	27.68	30.76	1.11	721.10	128.28	103.99	0.81
June	191	4.1	2.15	0.34	0.40	1.19	129.00	27.36	28.63	1.05	966.33	154.02	156.65	1.02
July	143	3.1	1.34	0.24	0.27	1.15	133.75	17.52	25.00	1.43	039.33	256.16	240.26	0.94
August	142	3.1	3.11	0.35	0.49	1.41	140.90	25.90	29.85	1.15	093.05	188.13	168.47	0.90
September	174	3.7	7.47	0.49	0.79	1.61	355.75	32.99	43.58	1.32	009.00	162.98	153.57	0.94
October	232	5.0	5.00	0.65	0.83	1.27	330.75	43.22	55.81	1.29	308.13	95.08	60.35	0.63
November	208	4.5	6.63	1.32	1.34	1.02	363.00	83.40	83.58	1.00	384.50	82.31	56.79	0.69
December	228	4.9	8.65	1.03	1.35	1.31	372.98	65.59	74.69	1.14	530.00	84.26	59.40	0.70
Total	2409	51.81												

48 Hour Rainfall Interevent Statistics (Summary)

11-Jul-95

Month	Event		Depth (in)				Duration (hrs)				Interevent Duration			
	Total	#/Year	Max	Avg.	St. Dev.	C.V.	Max	Avg.	St. Dev.	C.V.	Max	Avg.	St. Dev.	C.V.
January	149	3.2	12.97	1.76	2.26	1.28	113.67	129.71	160.51	1.24	360.07	118.04	69.34	0.59
February	142	3.1	7.03	1.21	1.46	1.21	863.00	101.14	127.53	1.26	402.00	106.35	61.12	0.57
March	172	3.7	4.00	0.85	0.98	1.15	448.75	85.21	92.95	1.09	465.00	106.63	70.38	0.66
April	188	4.0	5.12	0.55	0.69	1.25	455.67	62.40	75.90	1.22	508.12	120.31	81.98	0.68
May	191	4.1	4.10	0.38	0.51	1.34	319.67	40.51	51.30	1.27	721.10	141.40	106.01	0.75
June	158	3.4	2.34	0.38	0.45	1.19	228.50	38.62	42.76	1.11	966.33	177.26	162.83	0.92
July	125	2.7	1.34	0.27	0.30	1.11	163.25	25.25	33.47	1.33	039.33	286.50	242.31	0.85
August	122	2.6	3.59	0.40	0.56	1.40	203.00	37.10	44.80	1.21	093.05	213.10	169.35	0.79
September	148	3.2	7.47	0.58	0.89	1.55	355.75	46.01	57.12	1.24	009.00	184.39	157.05	0.85
October	195	4.2	5.76	0.87	1.13	1.31	503.53	66.69	91.61	1.37	308.13	106.51	60.03	0.56
November	148	3.2	13.54	1.84	2.01	1.09	931.50	133.66	146.83	1.10	384.50	99.67	59.30	0.59
December	166	3.6	8.75	1.38	1.69	1.23	588.75	104.04	117.98	1.13	530.00	99.42	62.65	0.63
Total	1904	40.95												

60 Hour Rainfall Interevent Statistics (Summary)

11-Jul-95

Month	Event		Depth (in)				Duration (hrs)				Interevent Duration			
	Total	#/Year	Max	Avg.	St. Dev.	C.V.	Max	Avg.	St. Dev.	C.V.	Max	Avg.	St. Dev.	C.V.
January	111	2.4	12.97	2.12	2.53	1.19	113.67	166.78	182.13	1.09	360.07	132.79	70.12	0.53
February	111	2.4	10.65	1.63	2.08	1.27	863.00	153.96	187.70	1.22	402.00	126.46	62.20	0.49
March	138	3.0	4.57	1.03	1.12	1.09	639.50	124.25	132.47	1.07	508.12	126.94	78.11	0.62
April	142	3.1	5.83	0.71	0.87	1.23	460.17	89.61	105.32	1.18	624.50	137.11	90.03	0.66
May	158	3.4	4.10	0.47	0.62	1.32	329.00	61.08	72.67	1.19	721.10	157.80	101.92	0.65
June	137	2.9	2.50	0.43	0.49	1.15	292.23	53.47	60.27	1.13	966.33	202.59	171.65	0.85
July	108	2.3	1.34	0.29	0.30	1.05	160.93	31.02	36.75	1.18	039.33	309.60	244.36	0.79
August	115	2.5	3.59	0.43	0.60	1.39	397.75	44.04	62.41	1.42	093.05	223.08	169.40	0.76
September	127	2.7	8.86	0.67	1.06	1.60	481.67	61.82	79.66	1.29	009.00	206.11	159.51	0.77
October	161	3.5	13.98	1.26	1.96	1.56	966.00	109.39	164.33	1.50	308.13	121.08	60.02	0.50
November	109	2.3	13.55	2.30	2.33	1.01	982.00	189.42	195.72	1.03	384.50	115.45	58.93	0.51
December	116	2.5	10.55	2.11	2.38	1.13	828.75	183.15	184.87	1.01	530.00	122.70	66.54	0.54
Total	1533	32.97												

72 Hour Rainfall Interevent Statistics (Summary)

11-Jul-95

Month	Event		Depth (in)				Duration (hrs)				Interevent Duration			
	Total	#/Year	Max	Avg.	St. Dev.	C.V.	Max	Avg.	St. Dev.	C.V.	Max	Avg.	St. Dev.	C.V.
January	96	2.1	12.97	2.32	2.65	1.14	113.67	196.90	210.65	1.07	360.07	144.74	69.72	0.48
February	91	2.0	11.47	2.09	2.67	1.27	189.50	212.43	261.37	1.23	402.00	143.08	65.91	0.46
March	110	2.4	4.62	1.21	1.16	0.96	744.00	165.84	161.92	0.98	508.12	139.95	76.60	0.55
April	114	2.5	5.83	0.84	0.97	1.16	521.88	120.24	136.00	1.13	624.50	153.52	92.59	0.60
May	138	3.0	4.10	0.56	0.76	1.36	591.00	82.06	98.61	1.20	721.10	180.43	111.94	0.62
June	119	2.6	2.34	0.45	0.50	1.10	463.50	64.43	73.35	1.14	966.33	211.16	171.81	0.81
July	104	2.2	1.34	0.30	0.31	1.04	160.93	34.68	39.41	1.14	039.33	319.04	244.13	0.77
August	110	2.4	3.59	0.46	0.62	1.34	397.75	52.50	69.86	1.33	093.05	233.50	168.69	0.72
September	113	2.4	8.86	0.74	1.16	1.57	481.67	75.49	96.28	1.28	009.00	220.62	161.46	0.73
October	132	2.8	13.98	1.65	2.25	1.36	012.87	164.23	220.18	1.34	308.13	135.33	58.90	0.44
November	93	2.0	19.63	2.91	3.32	1.14	752.93	252.06	294.26	1.17	384.50	127.98	59.08	0.46
December	91	2.0	10.55	2.50	2.68	1.08	828.75	225.06	214.94	0.96	530.00	133.61	68.02	0.51
Total	1311	28.19												

84 Hour Rainfall Interevent Statistics (Summary)

11-Jul-95

Month	Event		Depth (in)				Duration (hrs)				Interevent Duration			
	Total	#/Year	Max	Avg.	St. Dev.	C.V.	Max	Avg.	St. Dev.	C.V.	Max	Avg.	St. Dev.	C.V.
January	83	1.8	12.97	2.49	2.96	1.19	188.50	228.44	265.78	1.16	360.07	154.64	67.02	0.43
February	77	1.7	14.81	2.45	2.93	1.20	189.50	262.20	293.01	1.12	402.00	152.23	65.63	0.43
March	91	2.0	9.12	1.43	1.46	1.02	094.00	212.34	221.61	1.04	508.12	153.76	78.70	0.51
April	97	2.1	5.83	0.96	1.03	1.07	778.00	152.14	155.15	1.02	624.50	166.70	94.66	0.57
May	128	2.8	4.14	0.60	0.78	1.30	591.00	95.91	117.49	1.22	721.10	189.02	112.39	0.59
June	107	2.3	2.34	0.51	0.54	1.05	463.50	78.26	84.29	1.08	966.33	230.20	176.95	0.77
July	94	2.0	1.34	0.31	0.32	1.05	289.65	42.63	52.89	1.24	039.33	336.74	246.07	0.73
August	104	2.2	6.14	0.53	0.92	1.72	721.90	65.79	104.39	1.59	093.05	246.95	169.39	0.69
September	103	2.2	8.86	0.80	1.21	1.51	481.67	89.14	107.83	1.21	009.00	230.82	161.25	0.70
October	112	2.4	17.75	2.30	3.22	1.40	688.00	252.35	343.61	1.36	308.13	151.41	57.52	0.38
November	69	1.5	24.88	4.13	4.89	1.18	088.00	367.59	432.00	1.18	384.50	145.32	59.00	0.41
December	73	1.6	11.18	2.66	2.89	1.09	075.00	254.48	250.80	0.99	530.00	143.72	71.79	0.50
Total	1138	24.47												

96 Hour Rainfall Interevent Statistics (Summary)

11-Jul-95

Month	Event		Depth (in)				Duration (hrs)				Interevent Duration			
	Total	#/Year	Max	Avg.	St. Dev.	C.V.	Max	Avg.	St. Dev.	C.V.	Max	Avg.	St. Dev.	C.V.
January	65	1.4	13.95	2.85	3.17	1.11	376.67	293.56	330.41	1.13	349.00	165.26	59.34	0.36
February	63	1.4	14.85	3.00	3.46	1.15	727.00	331.19	348.58	1.05	402.00	164.91	65.15	0.40
March	77	1.7	5.12	1.58	1.32	0.84	006.85	254.40	217.21	0.85	508.12	166.95	85.32	0.51
April	77	1.7	5.93	1.20	1.16	0.96	778.00	209.99	186.69	0.89	624.50	181.13	94.40	0.52
May	119	2.6	4.14	0.68	0.87	1.28	720.75	117.55	146.64	1.25	721.10	198.53	112.01	0.56
June	97	2.1	2.34	0.50	0.51	1.02	332.00	81.58	80.08	0.98	966.33	241.86	181.48	0.75
July	89	1.9	1.51	0.33	0.35	1.07	348.00	50.15	65.35	1.30	039.33	350.52	245.71	0.70
August	98	2.1	6.14	0.58	0.97	1.67	721.90	80.75	127.93	1.58	093.05	262.27	166.17	0.63
September	94	2.0	8.86	0.90	1.31	1.45	699.00	107.64	128.72	1.20	009.00	239.61	165.15	0.69
October	100	2.2	19.75	2.63	3.69	1.40	888.50	297.87	408.21	1.37	308.13	160.37	56.05	0.35
November	60	1.3	24.96	4.76	5.09	1.07	191.75	445.85	465.02	1.04	384.50	152.09	57.34	0.38
December	60	1.3	14.17	3.62	3.77	1.04	381.00	366.56	363.49	0.99	530.00	166.83	80.31	0.48
Total	999	21.48												

120 Hour Rainfall Interevent Statistics (Summary)

11-Jul-95

Month	Event		Depth (in)				Duration (hrs)				Interevent Duration			
	Total	#/Year	Max	Avg.	St. Dev.	C.V.	Max	Avg.	St. Dev.	C.V.	Max	Avg.	St. Dev.	C.V.
January	42	0.9	14.83	3.97	4.28	1.08	654.00	440.75	461.40	1.05	402.00	190.10	66.06	0.35
February	44	0.9	14.85	3.74	3.56	0.95	727.00	469.26	432.06	0.92	343.00	185.29	58.43	0.32
March	58	1.2	7.29	2.39	1.74	0.73	473.38	454.24	342.84	0.75	508.12	205.79	93.94	0.46
April	52	1.1	5.93	1.40	1.32	0.95	160.00	284.59	264.89	0.93	624.50	208.58	94.40	0.45
May	89	1.9	4.14	0.88	1.09	1.24	119.00	174.44	225.60	1.29	721.10	227.63	116.26	0.51
June	75	1.6	2.56	0.62	0.61	0.98	705.83	130.05	141.56	1.09	966.33	282.45	194.44	0.69
July	73	1.6	1.99	0.37	0.42	1.12	461.98	72.17	101.55	1.41	039.33	389.03	246.35	0.63
August	88	1.9	6.14	0.69	1.10	1.59	721.90	119.77	162.07	1.35	093.05	288.85	162.82	0.56
September	74	1.6	21.40	1.42	2.83	1.99	559.00	201.69	432.07	2.14	009.00	268.71	169.51	0.63
October	76	1.6	22.75	4.28	5.64	1.32	506.50	512.97	631.78	1.23	357.20	186.72	54.92	0.29
November	43	0.9	26.73	6.61	6.60	1.00	531.75	660.76	653.38	0.99	530.00	176.07	73.38	0.42
December	37	0.8	19.36	5.00	4.17	0.83	175.00	579.81	477.12	0.82	360.07	196.05	69.51	0.35
Total	751	16.15												

144 Hour Rainfall Interevent Statistics (Summary)

11-Jul-95

Month	Event		Depth (in)				Duration (hrs)				Interevent Duration			
	Total	#/Year	Max	Avg.	St. Dev.	C.V.	Max	Avg.	St. Dev.	C.V.	Max	Avg.	St. Dev.	C.V.
January	30	0.6	19.19	3.72	4.38	1.18	581.00	461.13	593.87	1.29	402.00	203.26	64.77	0.32
February	34	0.7	14.85	4.94	3.79	0.77	204.80	724.32	588.97	0.81	343.00	211.14	51.80	0.25
March	38	0.8	10.72	3.42	2.43	0.71	155.75	721.09	572.29	0.79	508.12	246.81	106.11	0.43
April	36	0.8	5.93	1.56	1.35	0.87	368.50	343.12	301.77	0.88	662.33	250.60	120.18	0.48
May	63	1.4	4.49	1.13	1.24	1.09	240.00	264.93	292.76	1.11	721.10	253.94	105.04	0.41
June	54	1.2	2.66	0.89	0.74	0.83	814.00	234.26	195.05	0.83	032.33	361.56	218.26	0.60
July	63	1.4	1.99	0.39	0.42	1.08	611.50	98.32	133.88	1.36	039:33	417.60	233.33	0.56
August	80	1.7	7.14	0.78	1.23	1.57	220.67	142.48	202.77	1.42	093.05	299.05	162.04	0.54
September	68	1.5	21.88	1.74	3.14	1.80	701.00	262.54	491.88	1.87	009.00	278.66	169.44	0.61
October	65	1.4	37.60	6.08	8.08	1.33	096.00	752.85	929.56	1.23	530.00	213.20	68.65	0.32
November	33	0.7	26.73	9.18	7.51	0.82	798.00	989.24	836.82	0.85	384.50	189.83	56.48	0.30
December	25	0.5	25.59	6.62	6.53	0.99	621.00	874.44	886.37	1.01	349.00	212.10	60.93	0.29
Total	589	12.67												

168 Hour Rainfall Interevent Statistics (Summary)

11-Jul-95

Month	Event		Depth (in)				Duration (hrs)				Interevent Duration			
	Total	#/Year	Max	Avg.	St. Dev.	C.V.	Max	Avg.	St. Dev.	C.V.	Max	Avg.	St. Dev.	C.V.
January	22	0.5	19.19	4.79	4.70	0.98	581.00	601.93	615.25	1.02	321.20	213.96	62.07	0.29
February	26	0.6	15.62	5.77	3.98	0.69	456.00	908.70	652.81	0.72	444.50	228.20	65.51	0.29
March	30	0.6	12.64	3.90	3.19	0.82	954.78	815.02	744.71	0.91	624.50	269.56	122.97	0.46
April	32	0.7	8.14	2.08	1.85	0.89	076.92	541.27	518.90	0.96	662.33	270.49	114.78	0.42
May	50	1.1	3.69	1.01	1.01	1.00	119.00	265.61	287.27	1.08	721.10	283.27	110.62	0.39
June	45	1.0	4.23	1.03	0.88	0.85	148.48	280.14	240.15	0.86	032.33	393.24	222.24	0.57
July	56	1.2	1.51	0.39	0.39	1.00	611.50	106.33	144.07	1.35	039.33	434.29	236.21	0.54
August	72	1.5	7.14	0.92	1.34	1.45	554.00	195.63	276.52	1.41	093.05	320.30	161.03	0.50
September	59	1.3	38.10	3.87	7.81	2.02	500.00	588.22	1146.92	1.95	009.00	306.03	169.38	0.55
October	50	1.1	41.76	8.94	10.24	1.15	909.00	160.41	1237.07	1.07	530.00	237.50	59.45	0.25
November	22	0.5	26.55	11.16	7.69	0.69	626.00	376.49	943.90	0.69	402.00	236.75	73.21	0.31
December	11	0.2	25.59	9.98	7.57	0.76	821.93	498.34	1197.74	0.80	349.00	220.81	62.31	0.28
Total	475	10.22												

CSO GLOSSARY

Average dry weather flow — The average non-storm flow over 24 hours during the dry months of the year (May through September). It is composed of the average sewage flow and the average dry weather inflow/infiltration.

Average wet weather flow — The average flow over 24 hours during the wet months of the year (October through April) on days when no rainfall occurred on that or the preceding day.

Base flow — Wastewater flow (including a reasonable amount of inflow and infiltration) originating from residential, commercial and industrial sources.

Baseline study — A study that documents the existing state of an environment to serve as a reference point against which future changes to that environment can be measured.

Best Management Practice (BMP) — A method, activity, or procedure for reducing the amount of pollution entering a water body

Calibration — The determination, checking, or rectifying of the graduation of any instrument giving quantitative measurements. With respect to a computer model, calibration is a process whereby data recorded during an actual event is compared with data derived from a computer simulation of that event in order to determine the accuracy of the simulation.

CATAD system — Computer Augmented Treatment and Disposal System, which monitors flows in the wastewater conveyance system and operates regulator and pump stations to gain maximum use of pipe capacities.

Clean Water Act (CWA) — Also known as the Federal Water Pollution Control Act (33 U.S.C. 1251 et seq.).

Combined sewer overflows (CSOs) — Overflows, during wet weather, of combined wastewater and stormwater. CSOs occur when flows in the wastewater collection system exceed the capacity of that system. The term "CSO" is also sometimes used to denote a pipe that discharges those overflows.

Combined sewer system — A wastewater collection and treatment system where domestic and industrial wastewater is combined with storm runoff.

Combined sewers — A sewer that carries both sewage and stormwater runoff.

Cost-effective alternative — An alternative control or corrective method identified after analysis as being the best available in terms of reliability, performance, and costs.

CSO event — A period of rainfall during which an overflow was recorded and that was preceded by 48 hours with no overflow and followed by 48 hours.

CSO Treatment Plant — A plant designed to provide primary treatment of combined sanitary sewage and storm water for peak flows above the 2.25 times the average wet weather flow. Such plants operate only intermittently, unlike most wastewater treatment plants which operate continuously.

Design event — A computer-simulated combined sewer overflow event, usually based on a design storm, which is used to determine the probable response of the sewer system to proposed modifications.

Design storm — A rainstorm used in the design of wastewater systems, primarily for systems which control combined sewer overflows. A particular storm may be selected as a design storm because adequate data exist to allow a calibration of a computer model being used to simulate the behavior of the sewer system during that storm.

Detention — The process of collecting and holding back stormwater or combined sewage for delayed release to receiving waters.

Discharge, direct or indirect — The release of wastewater or contaminants to the environment. A direct discharge of wastewater flows from a land surface directly into surface waters, while an indirect discharge of wastewater flows into surface waters by way of a wastewaer treatment system.

Disinfection — A chemical or physical process that kills organisms which cause infectious disease. Chlorine is often used to disinfect treated sewage.

Diurnal base flow	Two peaks in the wastewater flow within the wastewater system in a single day
Domestic wastewater	Human-generated sewage that flows from homes and businesses.
Effluent	Treated water, wastewater or other liquid flowing out of a treatment facility.
Environmental assessment	A written environmental analysis which is prepared pursuant to the National Environmental Policy Act to determine whether a proposed action would significantly affect the environment and thus require preparation of a more detailed environmental impact statement.
Environmental Impact Statement (EIS)	A document that discusses the likely significant impacts of a development project or a planning proposal, ways to lessen the impacts, and alternatives to the project or proposal. EISs may be required by national and state environmental policy acts
Environmental Protection Agency (EPA)	A federal agency established in 1979 by Presidential executive order to control pollution of the environment.
Fecal coliform bacteria	A group of organisms common to the intestinal tracts of humans and animals. The presence of fecal coliform bacteria in water, wastewater, or biosolids is an indicator of pollution and possible contamination by pathogens.
Final Design	The final phase of a project's design process. During final design, contract plans and specifications necessary for bidding are prepared. These contract documents provide all the necessary information needed by suppliers and contractors to construct the facility.
Force main	A pipeline leading from a pumping station that transports wastewater under pressure.
Groundwater infiltration	Infiltration that enters the sewerage system through pipe defects located below the normal groundwater table.
Hydraulic	Pertaining to the energy, momentum, and continuity effects of liquid in motion. The term usually refers to the flow of liquids in natural environments (e.g., rivers) or man-made structures (e.g., pipes).

Hydrograph	The variation of the flow of liquids over time.
Hydrology	The science dealing with the properties, distribution and circulation of water. The term usually refers to the flow of water on or below the land surface before reaching a stream or man-made structure.
Hydraulic Routing Model	A computer model used to simulate the flow of water in King County's pipes.
Infiltration	The penetration of water from the land surface into the soil, or the penetration of water from the soil into a sewer system by such means as defective pipes, pipe joints or connections, or manhole walls.
Inflow	Flows of extraneous water into a wastewater conveyance system from sources other than a sanitary sewer connections, such as roof leaders, basement drains, manhole covers, and cross-connections from storm sewers.
Influent	Water, wastewater or other liquid flowing into a reservoir, basin or treatment plant.
Influent pump station	A pump station that pumps flow from an interceptor sewer into a treatment plant.
Infrastructure	Streets, water, sewer lines, and other public facilities basic and necessary to the functioning of an urban area.
Interceptor sewers	The portion of a collection system that connects main and trunk sewers with the wastewater treatment plant, thereby controlling the flow into the plant.
Lag	An interval of time before additional flow enters the system.
Lateral sewers	Pipes that receive sewage from homes and businesses and transport that sewage to trunks and mains.
MG	Million gallons, a measure of liquid volume.
mgd	Million gallons per day, a rate of liquid flow.

Model	A formal set of relationships that attempt to represent some processes of the real world. Some models are intended to explain causes and effects of processes, others are tools to estimate or project the results of those processes, even if the processes themselves are not fully understood.
Monitor	To systematically and repeatedly measure conditions in order to track changes. For example, dissolved oxygen in a bay might be monitored over a period of several years in order to identify trends in concentration.
National Pollutant Discharge Elimination System (NPDES)	Section 402 of the federal Clean Water Act, which prohibits discharge of pollutants into navigable waters of the United States unless a special permit is issued by EPA, a state, or (where delegated) a tribal government on an Indian reservation.
Nonpoint source pollution	Pollution that enters water from dispersed and uncontrolled sources (such as surface runoff) rather than through pipes. Nonpoint sources (e.g., stormwater runoff from agricultural or forest operations, on-site sewage disposal systems, and discharge from boats) may contribute pathogens, suspended solids, and toxicants. The cumulative effects of nonpoint source pollution can be significant.
NPDES Permit	Permit issued under the National Pollution Discharge Elimination System, which establishes reporting requirements and other conditions for discharge of pollutants to receiving waters.
Outfall	The exit point, usually a pipe or pipes where flow is discharged from the wastewater system into receiving water and which is engineered to ensure dispersion and dilution of the effluent in the receiving waters.
Pathogens	Microorganisms that can cause disease in other organisms or humans, animals, and plants. Pathogens include bacteria, viruses, fungi, or parasites found in sewage, in runoff from farms or city streets, and in water used for swimming. Pathogens can be present in municipal, industrial, and nonpoint source discharges.
Peak flow	The maximum flow expected to enter a facility.

Pre-design	The initial phase of a project's design process. The results of this initial phase are generally limited to determination of the alignment, layout and technology for the project.
Primary treatment	The first stage of wastewater treatment involving removal of floating debris and solids by screening and/or settling.
Pump Station	A structure used to move wastewater uphill, against gravity.
Raw sewage	Untreated wastewater.
Regulator	A structure that controls the flow of wastewater from two or more input pipes to a single output. Regulators can be used to restrict or halt flow, thus causing wastewater to be stored in the conveyance system until it can be handled by the treatment plant.
Runoff	That part of precipitation, snow melt, or irrigation water that runs off of the land surface into streams or other surface water instead of infiltrating the land surface.
Secondary treatment	Biochemical treatment of wastewater after the primary stage, using bacteria to consume the organic wastes. The secondary treatment step includes aeration, settling, disinfection and discharge through an outfall. Secondary treatment in conjunction with primary treatment removes about 85 to 90 percent of suspended solids in wastewater.
Sediment	Once-suspended material which has settled to the bottom of a liquid, such as the sand and mud that make up much of the shorelines and bottom of Puget Sound.
Sediment quality standards	Standards which identify chemical concentration and biological toxicity limits allowed in sediments which correspond to no observable acute or chronic adverse effects on biological resources and which do not pose a significant health threat to humans.
Sedimentation tanks	Tanks or tunnels for holding wastewater where floating wastes are skimmed off and solids settle by gravity. Settled solids, called "sludge," are pumped out for further treatment. Sedimentation tanks are also referred to as clarifiers.

Separation, total or partial
A method for controlling combined sewer overflow whereby the combined sewer is separated into both a sanitary sewer and a storm drain, as is the practice in new development. Separation may be total, in which case no stormwater is diverted to the sanitary sewer, or it may be partial, involving only the removal of runoff from streets and parking lots from the sanitary system.

Setpoint
A defined indicator point in an electronic or mechanical control system where an action takes place. In a sewage conveyance system, a setpoint is generally the liquid level or flow rate which causes a valve to be opened or closed or a pump to be activated.

Sewer
A channel or conduit that carries wastewater or stormwater runoff from the source to a treatment plant or receiving stream. Sanitary sewers carry household, industrial, and commercial wastewater. Storm sewers carry runoff from rain or snow. Combined sewers carry both kinds of water.

State Environmental Policy Act (SEPA)
A state law (Chapter 43.21C RCW) which requires that state agencies and local governments consider environmental impacts when making decisions regarding certain activities, such as development proposals over a certain size, and comprehensive plans. As part of this process, environmental impacts are documented and opportunities for public comment are provided.

Storage
A method for controlling combined sewer overflows by storing the combined sewage until the rain storm subsides, then releasing it back into the conveyance system to be treated at the usual treatment plant.

Storm drain
A system of gutters, pipes, or ditches used to collect and carry stormwater from buildings or land surfaces to streams, lakes, or other receiving waters. In practice storm drains carry a variety of substances such as sediments, metals, bacteria, oil, and antifreeze which enter the system through runoff, deliberate dumping, or spills. This term also refers to the end of the pipe where the stormwater is discharged.

Storm sewer
A system of pipes (separate from sanitary sewers) that carry only water runoff from building and land surfaces.

Stormwater	Water that is generated by rainfall and is often routed into drain systems in order to prevent flooding
Suspended solids	Small particles of organic or inorganic materials that float on the surface of, or are suspended in, sewage or other liquids and which cloud the water. The term may include sand, mud, and clay particles as well as waste materials.
Synthetic Unit Hydrograph	Estimates amount and pattern of rainwater due to a "unit" of rainfall flowing into the sewer system over a certain period of time. The pattern is than factored according to the amount of rainfall that actually fell for the time period. These individual patterns are then added for each time step to get the cumulative hydrograph from each basin.
Telemeter	To transmit to a distant receiving station by radio or other electronic means.
Toxic	Causing death, disease, behavioral abnormalities, cancer, genetic mutations, physiological malfunctions (including malfunctions in reproduction), or physical deformations in any organism or its offspring upon exposure, ingestion, inhalation, or assimilation.
Treatment	Chemical, biological, or mechanical procedures applied to industrial or municipal wastewater or to other sources of contamination to remove, reduce, or neutralize contaminants.
Washington Administrative Code (WAC)	The codified regulations adopted by various Washington state agencies through the rulemaking process.
Wastewater	Total flow within a sewerage system. In separated systems, it includes sewage and infiltration/inflow. In combined systems, it includes sewage and stormwater.
Water quality criteria	The levels of pollutants that are protective of water for drinking, swimming, raising fish, farming or industrial use.
Water pollution	The addition of harmful or objectionable material to water in concentrations or sufficient quantities to adversely affect is usefulness or quality.
Weir	An overflow section of a pipe.

Appendix F: Bibliography

2000 CSO Update Bibliography

Adolfson Associates, Inc., "Combined Sewer Overflow Public Notification Program Final Report." December 1999.

Adolfson Associates, Inc. "Draft Task 200: A Review of Policies, Planning Efforts and Related Studies, and the Implications to King County's Combined Sewer Overflow Planning." 1999.

Adolfson Associates, Inc. "Draft Task 410/420: Implications of the Endangered Species Act to King County's CSO Control Program," 1999.

Anchor Envrionmental/Herrera Environmental Consultants/King County. "Sedment Management Plan." Preliminary Final. June 1999.

Brown and Caldwell/Herrera Environmental Consultants. "2000 CSO Plan Update: Task 320 Technical Memorandum, Preliminary and Refined Research Criteria." 2000.

Brown and Caldwell/Herrera Environmental Consultants. "2000 CSO Plan Update: Task 340 Pilot Program Evaluation For the CSO Program." 2000.

Brown and Caldwell/Herrera Environmental Consultants. "2000 CSO Plan Update: Task 300 Technical Memorandum, Alternative Technologies for CSO Control." July 1999.

Brown and Caldwell. "CSO Control in King County: Draft Task 110 Technical Memorandum." 1999.

Brown and Caldwell. "King County's Regional Wastewater Services Plan: Draft Task 130 Technical Memorandum." 1999.

Brown and Caldwell. "Sediment Management Plan Implications to King County's CSO Control Program: Draft Task 200 Technical Memorandum." 1999.

Brown and Caldwell/KCM and Associated Firms. " RWSP: Final Task 4.0 Report, Development of Alternatives." December 1997.

Brown and Caldwell. "1995 CSO Update: CSO Event Definition—5 Year Update Task 16.01, Draft Technical Memorandum." September 1995.

Brown and Caldwell/KCM and Associated Firms. "RWSP: Final Task 5.0 Report, Supporting CSO Project Descriptions." August 1995.

Culp/Wesner/Culp Consulting Engineers, Municipality of Metropolitan Seattle. Technical Memorandum : Supplement to Final Plan for Combined Sewer Overflow Control. May 1986.

CWC-HDR, Inc., Ott Water Engineers.. "Final 1988 Combined Sewer Overflow Control Plan-Plan for Secondary Treatment Facilities and Combined Sewer Overflow." April 1988.

King County Department of Natural Resources. "Regional Wastewater Services Plan: Operational Master Plan." December 1999.

King County. Regional Wastewater Services Plan CSO Policies adopted by the King County Council; Ordinance No. 98-290. November 1999.

King County Department of Natural Resources. "1998/1999 Annual Combined Sewer Overflow Report." October 1999.

King County Department of Natural Resources. "King County Combined Sewer Overflow Water Quality Assessment for the Duwamish River and Elliott Bay, Summary." August 1999.

King County Department of Natural Resources/Parametrix, Inc. "King County Combined Sewer Overflow Water Quality Assessment for the Duwamish River and Elliott Bay, Volume 1: Overview and Interpretation." February 1999.

King County Department of Natural Resources. "Executive's Preferred Plan, Regional Wastewater Services Plan." April 1998.

King County Department of Natural Resources. "Regional Wastewater Services Plan, FEIS." April 1998.

King County Department of Natural Resources. "RWSP: Choices, Public Opinion Summary." November 1997.

King County Department of Natural Resources. "Choices, Draft Regional Wastewater Services Plan." May 1997.

King County Department of Natural Resources. "Choices, Draft Regional Wastewater Services Plan EIS." May 1997.

King County Department of Natural Resources. "Choices, Draft Regional Wastewater Services Financial Plan." May 1997.

King County Department of Metropolitan Services/Brown and Caldwell. "1995 CSO Update." February 1995.

Municipality of Metropolitan Seattle. "Final 1988 Combined Sewer Overflow Plan, Plan for Secondary Treatment Facilities and Combined Sewer Overflow Control." April 1988.

Municipality of Metropolitan Seattle. "Final Supplemental Environmental Impact Statement, Plan for Secondary Treatment Facilities and Combined Sewer Overflow Control, Volume IV." July 1986.

Municipality of Metropolitan Seattle. "Final Supplemental Plan for Combined Sewer Overflow Control, Plan for Secondary Treatment Facilities and Combined Sewer Overflow Control, Volume III." July 1986.

Municipality of Metropolitan Seattle. "Final Environmental Impact Statement, Plan for Secondary Treatment Facilities and Combined Sewer Overflow Control, Volume IV." November 1985.

Municipality of Metropolitan Seattle. "Final Plan for Secondary Treatment Facilities, Plan for Secondary Treatment Facilities and Combined Sewer Overflow Control, Volume II." November 1985.

Municipality of Metropolitan Seattle. "Final Plan for Combined Sewer Overflow Control, Plan for Secondary Treatment Facilities and Combined Sewer Overflow Control, Volume III." November 1985.

Municipality of Metropolitan Seattle. "Summary and Executive Director's Recommendations, Plan for Secondary Treatment Facilities and Combined Sewer Overflow Control, Volume I." November 1985.

Municipality of Metropolitan Seattle. Secondary Treatment Facilities and Combined Sewer Overflow Control Plan. Draft EIS, Public Hearings, Public Information Document. July 1985.

Municipality of Metropolitan Seattle. Secondary Treatment Facilities and Combined Sewer Overflow Control Plan, Draft EIS Technical Appendices. 1985.

Municipality of Metropolitan Seattle. "Combined Sewer Overflow Control Program." January 1979.

Washington Administrative Code (WAC). "Chapter 173-245 WAC, Submission of Plans and Reports for Construction and Operation of Combined Sewer Overflow Reduction Facilities." January 27, 1987.